JOURNAL OF

ENGINEERING EDUCATION

Articles

Do You Know 824

Mechanical Engineers and Nuclear Design — R. J. Fritz 827

Educational Requirements of Technical Editors — P. J. Kalsem 832

Why Do Engineers Dislike Technical Writing? — H. M. Friend 836

Microwave Engineering: How a New Course Is Adopted — Charles Süsskind 838

On Teaching Physical Mechanics — R. J. Seeger 842

Future Scientists of America Foundation — H. H. Armsby 855

Guidance Bibliography for Mathematics 858

Departments

New Members of ASEE 860

Teaching Positions Available 865

Reports

EJC: Professional Standards and Employment Conditions 866

Indexes to Volume 46 877

(Complete Table of Contents on page 823)

THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

JUNE, 1956 Vol. 46, No. 10

ROUTE SURVEYS AND CONSTRUCTION

Third Edition of *Route Surveys*

by HARRY RUBEY, *University of Missouri*

Here are the traditional fundamentals and disciplines of route surveys, design and construction—combined with data on professional civil engineering, contracting, professional management and practical photogrammetry. Designed as a permanent reference work, this book provides unusually complete tables and problems for all types of routes and can be easily adapted for any kind of route survey course.

Published April, 1956 640 pp $6.25

DESIGN OF REINFORCED CONCRETE

by BORIS W. BOGUSLAVSKY, *Aramco Overseas Company*

This text provides a sound introduction to structural theory, as applied to the analysis and design of reinforced concrete members, and to practical, up-to-date design procedures. Discussing first the fundamentals of structural analysis and basic individual structural members, the book progresses to a consideration of more complex structures and the subject of prestressed beams.

Published March, 1956 428 pp $7.50

PRINCIPLES OF TURBOMACHINERY

by DENNIS G. SHEPHERD, *Cornell University*

This first complete text for an integrated course in turbomachinery thoroughly discusses various methods of analysis and design and then applies these general principles to specific types of turbomachinery, such as pumps, fans, compressors and turbines.

Published May, 1956 463 pp $10.00

DESIGN OF MACHINE ELEMENTS, 3rd Edition

by VIRGIL M. FAIRES, *North Carolina State College*

Emphasizing the adaptation of theory to practical design, this text helps students master details of the subject and provides suggestions for more intense study of particular machine elements. The book features an intensive coverage and a practical, teachable organization of material that includes new design information for nearly every machine element.

Published February, 1955 550 pp $7.50

The Macmillan Company

60 FIFTH AVENUE, NEW YORK 11, N.Y.

N

route
n pro-
anage-
perma-
nplete
easily

$6.25

Com-

heory,
ncrete
Dis-
basic
a con-
of pre-

$7.50

turbo-
nalysis
o spe-
ressors

$10.00

dition
ollege
n, this
ovides
ne ele-
prac-
ew de-

$7.50

Now Available . . .

POWER PLANTS

By

Alexander H. Zerban

United Aircraft Corporation

and

Edwin P. Nye

The Pennsylvania State University

This revision was designed to meet the increasing demand for a coordinated treatment of the mechanical engineering of all types of commercial power-generation equipment. The title (formerly *Steam Power Plants*) was changed in order to reflect this broader coverage. The emphasis throughout is on application of the fundamental principles of science to the art of power engineering. The power plant is viewed as a vehicle to present the theoretical principles of thermodynamics and heat transfer in a context of working reality. An outstanding text for courses requiring an integrated study of power plants and related topics on a level above that of mere catalogue description. Outstanding features:

- The treatment of internal combustion plants has been reoriented and expanded.
- A new chapter on hydroelectric plants has been added.
- A new chapter discussing the problems and likely role of nuclear power is included.
- Greater emphasis has been placed on economic considerations.
- Many new problems have been added, bringing the total to over 500.

1956 *660 pages* *$6.50*

INTERNATIONAL TEXTBOOK COMPANY

Scranton 9, Pennsylvania

THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION
OFFICERS FOR 1955–56

President: M. M. BORING, Consultant, Engineering Manpower, General Electric Company, Schenectady, New York.

Vice President (general and regional activities): F. C. LINDVALL, Chairman, Division of Engineering, California Institute of Technology, Pasadena, California.

Vice President (instructional division activities): L. J. LASSALLE, Dean of Engineering, Louisiana State University, Baton Rouge, Louisiana.

Vice President (Engineering College Administrative Council): W. T. ALEXANDER, Dean of Engineering, Northeastern University, Boston, Massachusetts.

Vice President (Engineering College Research Council): H. K. WORK, Director of Research Division, New York University, New York 53, New York.

Treasurer: G. W. FARNHAM, The Ronald Press Company, New York, New York.

Secretary: W. LEIGHTON COLLINS, University of Illinois, Urbana, Illinois.

Editor of the Journal: E. C. MCCLINTOCK, University of Illinois, Urbana, Illinois.

Office Secretaries: NAOMI GARMAN, LOUISE CHAMBLISS, MARIE ROTH, and MURIEL DEA.

Junior Past Presidents: N. W. DOUGHERTY, L. E. GRINTER, W. R. WOOLRICH.

REPRESENTATIVES ON THE GENERAL COUNCIL

REPRESENTING DIVISIONS

Aeronautical—D. J. PEERY
Agricultural—R. H. DRIFTMEIER
Architectural—P. E. SONESON
Chemical—K. KOBE
Civil—A. J. MCNAIR
Cooperative Engineering Education—J. G. WOHLFORD
Educational Methods—E. B. STAVELY
Electrical—L. V. BEWLEY
Engineering Drawing—R. S. PAFFENBARGER
English—C. A. BROWN
Evening Engineering Education—C. E. SCHAFFNER
Graduate Studies—N. A. CHRISTENSEN
Humanistic-Social—D. STILLMAN
Industrial—F. F. GROSECLOSE
Mathematics—R. S. BURINGTON
Mechanical—E. E. AMBROSIUS
Mechanics—J. W. HOWE
Mineral—W. J. RUNDLE
Physics—R. J. SEEGER
Relations with Industry—A. R. HELLWARTH
Technical Institutes—C. S. JONES

REPRESENTING SECTIONS

Allegheny—W. I. SHORT
Illinois-Indiana—N. A. PARKER
Kansas-Nebraska—N. H. BARNARD
Michigan—R. H. SCHOONOVER
Middle Atlantic—R. W. VAN HOUTEN
Missouri-Arkansas—G. F. BRANIGAN
National Capital—H. H. ARMSBY
New England—E. T. DONOVAN
North Midwest—FRANK KEREKES
Ohio—H. K. JUSTICE
Pacific Northwest—R. D. SLOAN
Pacific Southwest—E. L. GRANT
Rocky Mountain—A. DIEFENDORF
Southeastern—H. FLINSCH
Southwest—M. R. LOHMANN
Upper New York-Ontario—R. F. EISENBERG

Society Headquarters: University of Illinois, Urbana, Illinois

ANNUAL MEETING—IOWA STATE COLLEGE
Ames, Iowa June 25–29, 1956

Published monthly (except during July and August) at Prince and Lemon Sts., Lancaster, Pa., by the American Society for Engineering Education under the Supervision of the Publication Committee: W. L. Collins, Chairman, M. M. Boring, N. W. Dougherty, T. Farrell, Jr., G. W. Farnham, M. E. Van Valkenburg, E. A. Walker, E. C. McClintock, Editor. Entered as second class matter, October 17, 1912, at the Post Office at Lancaster, Pa., under the act of August 12, 1912. Accepted for mailing at the special rate of postage provided for in section 132.122, P. L. & R., authorized April 5, 1956. Subscription Price, $6.00 per year; Yearbook Issue, $6.00; Single Copies, $1.25.

WILEY BOOKS

DESIGN OF PIPING SYSTEMS, 2nd Edition

Written by members of the engineering departments of the M. W. Kellogg Company. Completely rewritten and substantially expanded, the second edition offers a modern, comprehensive account of the entire subject of structural design of piping systems. It includes the most complete and detailed treatment of the thermal expansion problem ever published. Covered also are the effects of weight, wind and vibration; strength and failure of materials; bends, fittings, and branch connections; model testing, expansion joints, and pipe supports; and many other topics. *1956. 365 pages. $15.00.*

MOLECULAR FLOW OF GASES

By G. N. Patterson, *University of Toronto.* Approaching fluid mechanics from the molecular viewpoint, this book lays the foundation for a modern understanding of strong shock wave problems and the aerodynamics of high-speed, high-altitude flight. Its subject matter extends from the mechanics of rarefied gases to the relaxation and dissociation effects associated with strong shock waves. *1956. 217 pages. $7.50.*

THERMAL POWER FROM NUCLEAR REACTORS

By A. Stanley Thompson *and* Oliver E. Rodgers, *both of the Studebaker-Packard Corporation.* Discusses the three most important factors of nuclear power: the generation of heat in reactors; the removal of heat from reactors; and the use of this heat in thermal power plants. The work is unique in its application of numerical and dimensional analysis to nuclear design problems. *1956. 229 pages. College edition, $6.25.*

THE THEORY AND TECHNIQUE OF SHIP DESIGN

By George C. Manning, *Professor of Naval Architectuve, M.I.T.* A study of the basic principles and the processes employed in the design of ships of all classes. Partly based on the author's *Basic Design of Ships*, this book deals more fully than its predecessor with commercial vessels, and gives special attention to the technical, economic, and military considerations in determining the optimum form and displacement of vessels for any given duty. A Technology Press book, M.I.T. *1956. 278 pages. $10.00.*

Send today for your examination copies.

JOHN WILEY & SONS, Inc., 440-4th Ave., New York 16, N.Y.

A COMPLETE PRINTING SERVICE . . .

GOOD PRINTING does not just happen; it is the result of careful planning. The knowledge of our craftsmen, who for many years have been handling details of composition, printing and binding, is at your disposal. For seventy-five years we have been printers of scientific and technical journals, books, theses, dissertations and works in foreign languages. Consult us about your next job.

PRINTERS OF THE
JOURNAL OF ENGINEERING EDUCATION

LANCASTER PRESS, Inc.

PRINTERS · BINDERS · ELECTROTYPERS

ESTABLISHED 1877 LANCASTER, PA.

Selected RONALD Books

INTRODUCTION TO PLASTICITY

ARIS PHILLIPS, *Yale University*

NEW. Designed for senior undergraduate and first-year graduate students, this clearly developed introduction to metal plasticity requires only a knowledge of differential equations and elementary strength of materials. The first six chapters treat one-dimensional problems; the last three consider problems of combined stress. Covers axial loading and bending, behavior of indeterminate trusses, plastic bending, biaxial and triaxial loading, etc. Includes 87 selected problems. *"An excellent introductory book."* **GLENN MURPHY,** *Iowa State College.* *234 ills., tables; 230 pp.*

STATICS AND STRENGTH OF MATERIALS

JASPER O. DRAFFIN *and* **W. LEIGHTON COLLINS**
—both University of Illinois

A WELL-WRITTEN textbook suited for any course where the student begins the study of mechanics before completing the calculus. Covers in detail coplanar force systems, systems in space, use of light-weight alloys, high-strength steels, plastics. Methods make use of free-body diagrams, geometric interpretation, and physical visualization of problems. *"A very clear and concise treatment . . . excellent arrangement of subject matter."* **WILLIAM R. STAPLES,** *University of Saskatchewan.*
494 ills., tables; 398 pp.

HYDRO POWER ENGINEERING

JAMES J. DOLAND, *University of Illinois*

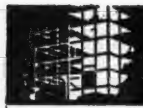
FOR CIVIL ENGINEERS—a textbook on design and preparation of plans for hydroelectric power installations. Presents basic theory; outlines the practical routine for selecting correct type, diameter of runner. Covers water passage design, proper number of units, etc.; includes analyses of public, private source material, plus original studies of hydro-power problems. *"One of the best texts—in scope, content, and method of presentation."* **H. W. COLLINS,** *Colorado A. & M. College.* *112 ills., tables; 209 pp.*

STEAM POWER PLANTS

PHILIP J. POTTER, *Alabama Polytechnic Institute*

THIS THOROUGH TEXTBOOK for advanced college courses relates engineering fundamentals to the design of steam power plants. Treats design of the large central station as well as industrial and smaller plants. Integrated specific examples show students how to apply principles. Treats flow of fluids, pumps, heat transfer, fuels, steam generators, boiler auxiliaries, draft equipment, feedwater, etc. *"A very well planned book."* **S. J. TRACY, JR.,** *College of the City of New York.*
328 ills., tables; 503 pp.

THE RONALD PRESS COMPANY • 15 E. 26th St., New York 10



For your engineering needs . . .

NEW & FORTHCOMING BOOKS

UNIT OPERATIONS OF CHEMICAL ENGINEERING

By WARREN L. McCABE, Polytechnic Institute of Brooklyn, and JULIAN SMITH, Cornell University. *McGraw-Hill Series in Chemical Engineering.* Ready for fall classes

Covers the unit operations of chemical engineering from both a practical and a theoretical standpoint. It is designed for undergraduate students in the junior or senior year who have the usual training in mathematics, physics, and mechanics. Each unit operation is given separate treatment. The text also covers fluid mechanics, flow of heat, and mass transfer, each giving scientific and theoretical foundations for several operations. The treatment of such topics as measuring instruments, mass transfer and the treatment of solids is unique. Most of the 500 figures were drawn especially for the text. A solutions manual will be available.

THE CHEMICAL PROCESS INDUSTRIES

By R. NORRIS SHREVE, Purdue University. Second Edition. *McGraw-Hill Chemical Engineering Series.* 1016 pages, $11.50 (text edition available)

A thorough revision of a highly popular chemical engineering text. Its aim is to present the processes used in the various chemical and allied industries, with the chapters arranged according to these various industries. The emphasis on flow sheets is one of its outstanding features, with new ones added and obsolete ones removed in this new edition. The object of the book is to give in one volume the modern chemical engineering way of looking at chemical and allied processes.

CHEMICAL ENGINEERING KINETICS

By J. M. SMITH, Purdue University. *McGraw-Hill Series in Chemical Engineering.* Ready for fall classes

Here is the first book to combine applied kinetics and the engineering problems of reaction equipment design in a manner suitable for seniors or first year graduate students. It attempts to bring to students and practicing engineers the combination of kinetics and reactor design necessary to design, construct, and operate reaction equipment. In a different kind of engineering approach, the author introduces and emphasizes the engineering problems encountered in designing and operating reaction equipment. Numerical examples of all important principles are included.

AIR POLLUTION HANDBOOK

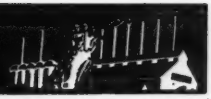
By the STANFORD RESEARCH INSTITUTE—Edited by PAUL L. MAGILL, FRANCIS R. HOLDEN, and CHARLES ACKLEY. In press

Offers much helpful theoretical, technical, and practical information on the problem of air pollution, its causes, effects, and control, in convenient reference form. Written by a number of specialists, the book is highly authoritative in each aspect of the problem it covers. It brings together the pertinent facts needed by all types of readers concerned with the problem of air pollution.

Send for copie on ap

McGRAW-HILL
330 West 42nd Street

from McGRAW-HILL



Four volumes by BERNHARDT G. A. SKROTZKI, Associate Editor, Power, constituting the McGraw-Hill Electric Utility Library. These books, for those in the beginning or lower stages of electric utility industry work, provide a practical knowledge of the design, operation, and maintenance of the equipment that makes up an electric-supply system. They are written in simple language, and with a minimum of mathematics.

ELECTRIC GENERATION—Hydro, Diesel and Gas Turbine Stations

480 pages, $8.50

Deals with central stations other than steam-electric, describing their fundamentals, their distinctive equipment and operations, and their part in the whole electric supply system. A description of the various types of hydraulic turbines and gas turbines and how they are arranged and controlled is also given.

ELECTRIC GENERATION—Steam Stations

480 pages, $8.50

Covers coal, gas, or oil burning steam-electric generating stations, describing their basic principles in simple terms. A practical treatment is given of such subjects as fuels, piping, feedwater treatment, control methods, and electrical systems. An introduction to the steam tables used for calculating and designing steam equipment is included, in addition to a review of preliminary proposals for applying nuclear energy in central stations.

ELECTRIC TRANSMISSION AND DISTRIBUTION

448 pages, $7.50

Explains the elements of direct- and alternating-current theory, the principal parts of transmission and distribution systems, including circuits, capacitors, transformers, auxiliaries, system protection and street lighting. Material is included showing how electric utility loads vary and how they may be forecast for planning future construction of transmission and distribution systems.

ELECTRIC SYSTEM OPERATION

416 pages, $6.50

Describes the system from fuel input and water flow to the customer's connections. All operations involved in scheduling and maintaining equipment to produce electrical power load economically and efficiently are shown. Included also is information on such subjects as relays, load dispatching and control, system communications, operating costs, and rate schedules.

on approval

BOOK COMPANY
New York 36, N. Y.

NEW McGraw-Hill Books

ASME HANDBOOK—Engineering Tables

Edited by JESSE HUCKERT, The Ohio State University. Sponsored by the American Society of Mechanical Engineers. 704 pages, $12.00

A reference book which makes available many tables of recognized design standards not commonly found in handbooks. This wealth of information makes design calculations easier, giving the engineer a ready source of design information to supplement his knowledge of standards for shape, dimension, gears, etc. Its fifteen sections group together tables applying to the design of specific parts.

ELECTRONIC ENGINEERING

By SAMUEL SEELY, Case Institute of Technology. *The McGraw-Hill Electrical and Electronic Engineering Series.* 532 pages, $8.00

Provides a physical and mathematical discussion of electronic circuits important in almost every field of electronic engineering. Included is a general introduction to tubes and tube circuit principles, and a detailed consideration of the more important electron tube circuits. Emphasis is on the physical and mathematical analyses. Develops in the student a solid understanding of the techniques of analysis, the special features of the many circuits examined and the means for combining circuits of different types to achieve required operational results.

RADIO ELECTRONICS

By SAMUEL SEELY. *The McGraw-Hill Electrical and Electronic Engineering Series.* 496 pages, $7.00

A companion volume to ELECTRONIC ENGINEERING which discusses in considerable mathematical detail the essential processes and circuits of importance in the field of radio communications. Starting with a general discussion of the methods of communication, it then expands in detail the more important aspects of the field. Emphasis is on the physical and mathematical analyses, so as to give the student an understanding of fundamentals underlying the broad field of communication.

MECHANICAL ENGINEERING PRACTICE
***New Fifth Edition:* A Laboratory Reference Text**

By CHARLES F. SHOOP, University of Minnesota; and GEORGE L. TUVE, Case Institute of Technology. 486 pages, $7.00

This combined text and handbook has been revised with continued emphasis on the scientific fundamentals of engineering instruction and their applications. Special stress is placed on new techniques for mechanical measurements, dynamic characteristics of processes, and automatic control. This new edition reflects such trends as the greater use of electrical instruments and transducers and the study of the dynamics of the processes of flow and heat transfer.

SEND FOR COPIES ON APPROVAL

McGRAW-HILL BOOK COMPANY, Inc.
330 West 42nd Street New York 36 N. Y.

The Journal of ENGINEERING EDUCATION

June, 1956 *Table of Contents* Vol 46, No 10

Articles

Do You Know		824
Mechanical Engineers and Nuclear Design	R. J. Fritz	827
Educational Requirements of Technical Editors	P. J. Kalsem	832
Why Do Engineers Dislike Technical Writing?	H. M. Friend	836
Microwave Engineering: How a New Course Is Adopted	Charles Süsskind	838
On Teaching Physical Mechanics	R. J. Seeger	842
Future Scientists of America Foundation	H. H. Armsby	855
Guidance Bibliography for Mathematics		858

Departments

New Members of ASEE	860	Teaching Positions Available	865

Report

EJC: Professional Standards and Employment Conditions 866

Notes

Journal Microfilm Editions	826	A. H. Cooper Ass't Director	857
EJC Proceedings Available	835	Gordon Research Conferences	859
CE-AGC Cooperative Committee	837	Risk Analysis—Discussion	859
Discussion—Nuclear Research Projects	857	Melvin L. Enger	864

Indexes—Volume 46, Nos. 1–10 (Sept., 1955–June, 1956)

Subject-Title	877	Author	880

DO YOU KNOW . . . .

► . . . . That two changes in the method of handling funds granted the Society for special studies were adopted by the Executive Board at its April meeting? One vote was, "When money is solicited by the Society in the name of the Society, the money is to remain under the control of the Secretary's Office and be disbursed as required." Such action should eliminate situations in which there seems to be uncertainty about authority and responsibilities.

The other vote was, "Not to pay travel expenses for industrial members of committees attending meetings and that such a statement be incorporated in agreements with the grantors of funds." This practice is not entirely new, but was necessary to avoid the recurrence of some embarrassing situations. It also may be well to state the Society pays no expenses for anyone attending the Annual Meeting, not even for the President.

► . . . . That officers appointed to ad hoc committees will now continue to serve until the work of the committee is completed, regardless of whether or not they are still in office? This policy was established at the April meeting of the Executive Board. A good horse should not be changed in mid-stream just because he goes out of office. One exception to this policy is the ECRC Chairman's appointment to the National Research Council; though he is appointed for a three-year term, he is expected to resign at the end of the second year in order that the new Chairman of ECRC can represent the Society for two years.

► . . . . That the Industrial Fellowship activity becomes a function of the Secretary's office as of 1 July 1956? This action of the Executive Board was taken after much discussion of how the Society should function. Based on the general principle that the Society should not establish several small secretarial staffs to conduct its work, the Executive Board voted, "That as of 1 July 1956 the Industrial Fellowship activity be transferred to the Secretary's office, that the activity then become a Society function, and that a new Society committee be appointed from ECAC and ECRC, the purpose of the committee being to carry out the 'random selection' of institutions and to advise the Secretary on other matters pertinent to the fellowship program."

► . . . . That an inquiry has been received about the interest in a group insurance plan for members of ASEE? Most of you probably know that ASCE has such a plan for its members. Smith and Sternau now are approaching the other constituent societies of Engineers Joint Council. The Executive Board voted not to participate in the plan because if the other societies adopt it most of our members will have an opportunity to participate.

► . . . . That the Dean's Conference on Atomic Energy is to be held at Gatlinburg, Tennessee, on September 5–8? Deans of engineering schools having ECPD accreditation, the presidents of those institutions, the members of our Atomic Energy Education Committee, and the President and Secretary of ASEE are to

be invited. The program is being developed by our AEEC in conjunction with AEC, NSF, ORINS, and ORNL. The official title could be the "ASEE-AECNSFORINSORNL Conference." The grant of funds from the National Science Foundation is dependent on the forthcoming action of Congress.

► . . . . That if you are 65 years *young*, have retired from active professional life, and have been in good standing for twenty-five years or more you may become a life member by vote of the General Council? Then you are exempt from the payment of dues. All you need to do is make a written request of the Secretary.

► . . . . That the Constitution also states you may become a life member by the lump sum payment of dues for twenty years? We have just discovered one such life member. Are there others? Are others interested?

► . . . . That a recent study disclosed that we have 62 living members who joined the Society in 1910 or earlier?

► . . . . That we need someone's help? A manuscript marked "(DRAFT)" with no name or other means of identification was sent to us. It is well prepared, typed, double spaced, edited in pencil, eight pages long, on Eminence Bond onion skin paper, and in the area of Engineering Science. If the author identifies his work we will be happy to consider it for publication in the JOURNAL.

► . . . . That copies of the report on the Humanistic-Social Research Project are now available from this office? Each of you will want to read it, just as you read the Evaluation Report. The cost is 25¢ per copy, 20¢ each in lots of 50 to 100, and 12¢ each in lots of 100 or more.

► . . . . That "Educational Aids in Engineering" are still available at $1.00 per copy? If you are in civil, electrical, or mechanical engineering, mechanics, or mathematics you should have a copy; many good ideas are presented. If you don't want a copy, does your library have one?

► . . . . That a copy of Educational Television Newsletter has been received? It tells of recent developments in various states and in various schools. However, there was nothing about courses in engineering. Has anyone been experimenting?

► . . . . That the *Proceedings* of the Society, since 1949, have been microfilmed? The work is done by University Microfilms, 313 N. First Street, Ann Arbor, Michigan and copies are sold by them to bona fide subscribers of the JOURNAL OF ENGINEERING EDUCATION at the end of the volume year, at which time the entire volume is delivered.

► . . . . That ECPD voted, "That the Council (ECPD) recommend to each constituent engineering society that they request each new member who joins a particular society to signify his acceptance of the Canons of Ethics, or of the code of ethics of the Society, as a condition of membership"? The Executive Board agreed that ASEE should not require new members to signify acceptance of a code. Most members accept such codes by virtue of membership in other societies; for non-engineer mem-

bers it does not seem desirable to have them agree to comply with an engineering code. They should, of course, know what the codes are.

► . . . . That it is a good idea for each of you to tear page 16 out of the 1956 Yearbook? Do it now! It is a membership application form, placed there for your use. Have it filled out by a cohort who is a non-member. Our present 8500 members represent only a small fraction of our potential! If you can't locate enough Yearbooks to meet your needs, we will be pleased to send you separate membership application forms—as many as you wish. Outstanding contributions already have been made, notably by W. D. McIlvaine of the University of Alabama, and by Wentworth Institute of Boston, Massachusetts. The former obtained many individual members, at least three associate institutional members, and contacted over fifty industries in his geographical area. Wentworth had 14 individual members and gained an additional 17. We congratulate both on their achievements! Are you doing your share?

► . . . . That the office staff wishes each of you a pleasant summer—of work, of vacation, or both?

W. Leighton Collins
Secretary

MICROFILM EDITIONS OF THE ASEE JOURNAL AND PROCEEDINGS NOW AVAILABLE

The Journal of Engineering Education, without advertisements, is now available through microfilm copies of the *Proceedings*, volumes 56–61. The microfilm is a positive copy furnished on labeled metal reels. Volume 56 (1948–49) is priced at $1.70; volume 57 (1949–50), volume 58 (1950–51), and 60 (1952–53) are $1.80; volume 59 (1951–52) is $1.60; and volume 61 (1953–54) is $2.00. Later volumes, at about $2.00 each, will be issued annually by University Microfilms, 313 North First Street, Ann Arbor, Michigan, from whom copies can be ordered. The availability of the Journal in this form is an indication of its growing importance as a source of advanced and authoritative ideas on engineering education and research.

MECHANICAL ENGINEERS AND NUCLEAR POWER REACTOR DESIGN

ROBERT J. FRITZ

Engineer, Knolls Atomic Power Laboratory, Schenectady, New York

Second paper from the oral presentation at the ASEE session of the EJC Nuclear Engineering and Science Congress, this revised form has been prepared for the Atomic Energy Education Committee Conference of the 64th Annual Meeting on June 28, 1956.

Educational requirements for the nuclear engineer should not be considered as something unique. They are based on the same principles and concepts that underlie all branches of engineering. Nuclear engineering differs from the established fields of engineering mainly in its newness, and it is because of this newness, this lack of experience, that the nuclear engineer must rely on his knowledge of basic scientific principles, applied with engineering judgment. In most of its technical aspects, nuclear engineering education can, therefore, be integrated with the present trends of engineering education.

Typical Problem

To bring out the nature of the problem that faces the nuclear engineer, consider as typical the design of mechanisms to control a nuclear reactor. A reactor is a furnace in which heat is generated by nuclear fission. A control system must both regulate the nuclear reaction and provide for power changes or rapid shutdowns. Mechanisms may be used to transmit specified motions from mechanical drives (which are usually located outside a pressure vessel) into the region of the reactor core, where certain materials are moved to affect the nuclear reaction. The mechanisms must penetrate the pressure vessel, so that seals must be provided to maintain leak-tightness. Radioactive fluids must be kept in and contaminants must be kept out. The engineer must establish what leak rates are allowable. Different materials must be considered for porosity, possible radiation damage, possible chemical attack and temperature effects. Seal designs must be conceived and tested to meet the specific objectives of leak-tightness under conditions which realistically simulate service requirements. The pressure vessel must be examined at the penetration to assure leak-tight integrity and strength under a variety of loads including those due to pressure, thermal gradients and piping reactions.

Since the control motion is accurately specified in space and time, there may be a problem of dynamics to determine how the interaction of friction, mass and flexibility will modify the motion.

To guide the motion accurately, bearings must be used, which may function in possibly corrosive fluids, in regions of high temperature, and under nuclear radiation. Bearing wear must be investigated and the bearings must be proof-tested.

Materials and design configurations must be chosen to minimize leakage of nuclear radiation, and additional shielding added where necessary. In the case of replaceable parts, the

materials must not contain long-lived radioactive elements. Heat transfer problems in forced and natural convection or by steady-state and transient conduction must be solved, from which temperature distributions in critical parts can be determined. From these temperature distributions, thermal stresses and deformations must be evaluated in order to prove that the assembly will not malfunction as a result of thermal distortion or thermal stress fatigue. Finally, limitations on thermal and pressure stresses must be established for which commonly accepted construction codes may not apply.

After much preliminary study and testing of components, an overall design is at last determined. A prototype is then built which, along with previous component prototypes, serves to test the manufacturing feasibility. The design must be susceptible of fabrication at a reasonable cost and with available materials. This prototype is subjected to performance tests. Changes in the design are made as indicated by the test results and by the experience of the shop in producing the components.

The design of such components entails a knowledge of heat transfer, fluid dynamics, structural analysis, nuclear physics, metallurgy, chemistry, and manufacturing practices, and requires techniques of experimental and theoretical analysis. Most likely the team effort of mechanical designers and specialists is required. In this new field, an important concept involves the technical team of the mechanical designer, who possesses a broad understanding of the various fields, and of specialists, who possess depth of understanding in their particular field, as well as knowledge of specialized techniques.

At the Knolls Atomic Power Laboratory, these specialists may be called on to advise the designer in conceptual design in order to define and interpret design requirements. Theoretical and experimental programs of a highly specialized nature become the responsibility of the specialist. These theoretical evaluations may involve the use of analog or digital computers, network analyzers, flux-plotting equipment or special mathematical techniques, and may be in the fields of physics, chemistry or metallurgy, or in the engineering specialties, such as applied mechanics. The experimental investigations may be component testing employing radioactive testing techniques or may be experimental programs in support of theoretical evaluations. Other development testing is the responsibility of the engineer.

At the Knolls Atomic Power Laboratory, the engineer is assisted by semi-professional workers, who contribute to the projects as engineering calculators, in production and design follow-ups, as laboratory technicians, drafting designers, and specification and instruction book writers.

This problem typifies the demands of nuclear engineering. The designer must have a broad knowledge of fundamentals, primarily in heat transfer, structural analysis, nuclear physics and metallurgy. He must have a broad understanding of manufacturing practices to assist the shop in fabrication. He must make effective use of engineering experiments in order to prove that his design will function reliably under realistic operating conditions. He must rely on the advice of and cooperate with specialists to

evaluate special problems in theoretical and experimental analysis.

Although the problem of nuclear power plant design is basically related to that of any other engineering activity, significant differences exist, too. There is a higher premium on reliability in the design of basically new types of power plants. Accurate control of quality is necessary in order to compare the efficiencies of basic designs. Moreover, the potential hazards to operating personnel, the public, and property are much greater with nuclear power systems than with conventional power plants. As a consequence, the nuclear engineer must not accept usual design solutions and safety factors without careful examination. Manufacturers who furnish components are frequently asked to supply special information and to make special tests as assurance that their products can withstand particular service requirements. For instance, the nuclear engineer may think of leak-tightness in terms of mass-spectrometer leak tests, which is a relatively new concept for such large-scale components. Lacking service experience, the nuclear engineer must have a sound understanding of his service requirements and of scientific principles, so that he can correlate these requirements with equipment characteristics.

Educational Requirements

This discussion will consider undergraduate engineering training, assuming that specialization in any particular field will be reserved for the graduate program. The needs of the designer and specialist would be served by the same undergraduate curriculum, with the possible exception of a small percentage of electives coming in the senior year. From what has already been said, it is recommended that this undergraduate program should be basically in mechanical engineering with a heavy emphasis on fundamentals and on mathematical tools to use these fundamentals, including studies in modern physics. The student should be introduced to the practices and limitations of standard engineering measurements, including the use of thermocouples, strain gages, and other measurement techniques and devices. His mathematical training should stress utilization and include numerical analysis. Engineering problems as they apply to nuclear power plants should be incorporated wherever possible in the undergraduate work. Because the nuclear engineer must operate in a project organization, he must be trained in effective communication.

For the four-year engineering curriculum, a one-semester course in Nuclear Physics would be considered satisfactory. It is recommended that a good text in modern physics be used in preference to one covering only reactor theory. This is in line with the basic recommendation of teaching fundamentals where possible in preference to specific applications. Some thought should also be given to associating or comparing the principles of modern physics with those of classical physics and mechanics. For example, the Newtonian expression for kinetic energy can be shown to be an approximation of Einstein's mass-energy law.

It is recommended that the mechanical engineering course be weighted heavily with fundamentals. This would imply that applications should be taught mainly to assist in the understanding of basic concepts and

scientific principles, and to illustrate the engineering method. Courses like metallurgy should only include fundamentals, which will furnish a foundation on which the nuclear engineer can develop deeper understanding as new experience becomes available to him in his field.

Elective Courses Possible

Poincaré, the French mathematician and philosopher, observed [1] that it is impossible to study the works of the mathematicians without noticing two opposite kinds of minds. The one sort are all preoccupied with logic, and they apparently advance step by step in a problem solution. The other sort are guided by intuition, and they attempt to arrive at a solution with a quick but sometimes precarious stroke. Many of us may have observed similar tendencies in engineers. We might distinguish these two types as analysts and synthesists. In the development of many engineering components, the engineering is relatively simple, so that the arts of the synthesist, that is, the one who brings things together to create a design, and of the analyst, or the evaluator, are combined. Assurance that the design will operate successfully can be gained by relatively simple calculation, by testing, or by referring to experience.

In nuclear engineering, however, where experience is lacking, where testing is expensive, and where safety requirements and the high cost of repair due to radioactive inaccessibility put a high premium on reliability, the importance of analysis increases. This necessitates a high degree of analytical training and a knowledge of specialized techniques for engineering evaluation. It has been my observation that engineers tend to develop either as synthesists with broad information, or as specialists and analysts with detailed knowledge of a few particular fields, such as heat transfer or other branches of applied mechanics. I do not mean to infer that some engineers do not combine these talents. It is difficult, however, to find an engineer who becomes outstanding in both fields. It is possible that these differences in engineering function of the analyst and synthesist should be recognized by offering a small number of differently-directed elective courses.

Designs will be created primarily by the synthesists. The potential designer must be taught the creative approach [2] and should be given homework assignments which require exercising the imagination and extensive library work. An avid thirst for knowledge was one of Thomas Edison's traits. He read extensively in an attempt to keep up with technical advances both in this country and abroad. Homework problems requiring extensive library work are intended to introduce the student to the great reservoir of information available in libraries, government publications, and trade journals.

The analyst, on the other hand, will contribute to the project primarily as an evaluator of designs. He derives his creative satisfaction from synthesizing principles and techniques of mathematical logic, and would profit

[1] H. Poincare, *Foundations of Science*, translation by G. Halsted, p. 210, Science Press, Lancaster, Pa., 1946.

[2] See, for instance, "Developing a Useful Imagination," by E. K. Von Fange, *General Electric Review*, September 1955, p. 52; and "Solving Engineering Problems," by C. F. Hix and D. L. Purdy, *Machine Design*, October 1955, p. 242.

by being offered courses in higher mathematics as well as special techniques in numerical analysis.

Study of the Humanities

Engineering education for the nuclear engineer must also include studies of the humanities. Since nuclear technology produces effects on both a national and an international scale, those men who will eventually become leaders must develop a broad social perspective. The colleges can serve to establish a foundation upon which further development can proceed effectively.

Conclusion

I am grateful for the opportunity to express my views. That I have recommended a strengthening of the mathematics and basic sciences underlying engineering education is probably in agreement with most recommendations from industry, especially in the new fields of commercial application. It is my impression that these goals are mutually acceptable to engineers and engineering educators. The problem seems to be primarily in finding the best ways to achieve these goals as presently defined.

Furthermore, my recommendations do not by any means imply a five-year undergraduate program. I personally favor the four-year program as a satisfactory compromise not only for those who will be engaged in fields of engineering such as manufacturing and sales, but also for those who will eventually pursue purely technical development.

I recognize that engineering education is a dynamic activity, always seeking to improve. Much of this improvement will no doubt come by the experimental process and by investigation to see how various educational programs answer the needs of industry. I hope I have been able to add something to your information about the needs in nuclear engineering.

EDUCATIONAL REQUIREMENTS FOR TECHNICAL EDITORS

P. J. KALSEM

Engineering Division
The Glenn L. Martin Company
Baltimore, Maryland

> TECH. EDITOR for large engr. firm M.E. Deg. required. Writing exp. or training not essential. Box 707.

This advertisement is typical of many attempts to fill a relatively modest, but persistent, demand for people who can write and edit technical material. Such advertisements reflect a tendency among employers to specify that technical editors must be engineering graduates. There are definite disadvantages, however, to restricting the source of technical editors in this way, for experience has proved that there are other desirable sources of such talent.

The pro-engineer side of the argument has been presented by Hamlett (1) of Sperry Gyroscope and by McDaniel and Scarlott (2) of Westinghouse. Their stand is backed by S. P. Olmsted (3) in describing the Rensselaer Polytechnic Institute graduate curriculum leading to a Master of Science degree in technical writing. This program is "based on the assumption that a full undergraduate engineering education, or an equivalent education in science, is a prerequisite to a career in technical writing." Rensselaer goes so far as to put out the "unwelcome" mat for certain liberal arts graduates: "No English majors need apply" (3).

But do engineers actually make the best technical editors? Are the personal qualities and training that make a man a good engineer the same ones that would make him a good writer or editor? I am inclined to doubt it, although I cannot point to extensive psychological studies of this problem. At any rate, the work of the engineer and that of the editor are substantially different, and it is reasonable to assume that the qualifications may also be different.

The engineer has basic responsibilities in analysis, design, or testing; to him, communication is an important but "sideline" activity in which he is seldom fully trained or experienced. His training and background have taught him to be adept, or most adept in communication via blueprints, mathematical equations, and graphs or charts.

The editor, on the other hand, is almost wholly engaged in the communication of ideas, with emphasis on the printed word and accompanying illustrations. As an editor, he must have enough background to *understand* the engineering ideas concerned, but his primary attribute is the ability to *communicate* them effectively to his readers.

In writing about the qualifications of technical editors, Dwight E. Gray (4), of the Technical Information Division, Library of Congress, states that a technical editor "should have had enough formal training . . . first, to give him an appreciation of science

and an understanding of the ground rules by which scientists operate and, second, to enable him to follow with reasonable intelligence the trend of thought in most of the reports that come to him for editorial diagnosis and treatment." This requirement certainly does not indicate the necessity for completing a full engineering or science curriculum as we know it today in most colleges.

The problem hinges partly on what industry requires of a technical editor. In many companies, the editor is considered an important part of the organization, and this is now reflected in the excellent financial opportunities available to him. Consider the typical case of an editor employed in the publications section of a laboratory or engineering department. If he has a true perspective, he realizes that his is a service function.

In one sense, he stands midway between the engineer-author and the reader, representing each to the other and serving the interests of both. In another sense, the engineer and the editor can be thought of as an entity: the efforts of both are combined to secure the most effective final result.

In a typical situation, the basic material is supplied by the engineer, generally in rough draft, and "writ by hand." Typical weaknesses in such rough drafts include incomplete summaries and introductions, poor arrangement of material, confusing paragraphs or sections, mistakes in grammar, inconsistencies in style, "deadwood" or wordiness, and lack of suitable illustrations.

To correct these weaknesses, the editor tackles the paper with his blue pencil, interviewing or challenging the engineer as needed. The rough draft is passed back to the engineer with editorial "improvements," some of which may not be satisfactory to the author. The material continues to be so exchanged for re-working and discussion until both engineer and editor are satisfied and, theoretically, the best interests of the reader have also been served.

Suppose, however, that the engineer and the editor are nearly identical in personal traits, and that both are trained as electronics engineers. Ideal communication would then exist between engineer and editor. The editorial process is relatively short and no one suffers, that is, no one except the neglected reader who more often than not will be a financial expert, engineering manager, or military administrator—without a technical background.

It is clear the reader would be better represented by an editor with broad training and knowledge, which includes not only editorial tools and engineering fundamentals but a knowledge of business administration, law, economics, and other social studies.

Also, in the case of progress reports and proposals, the author is not just one engineer, but a group of specialists in several different fields. Here again a broad background is advantageous to the editor. He must take writing with many individual differences, iron out the inconsistencies, and present a united front in the final effective product.

Examples of technical or semi-technical writing addressed to readers without extensive engineering training are numerous: over-all design summaries, progress reports, proposals for new business, documentary motion pictures, articles for submission to journals, oral presentations to administrators, training manuals and

handbooks. To such papers the editor with proper training can contribute a great deal; he can both complement the enginer and compensate for the engineer's weaknesses.

The less technical the reader, the greater will be the effort required of the editor. In extreme cases, the editor may do the entire writing job—basing it, of course, on interviews with the engineers.

At the other extreme, where an engineer is writing to fellow engineers (for instance, an aerodynamicist writing to other aerodynamicists on airplane drag analysis), the editor may merely supervise the report organization, style, and publication process—in many instances, a minor professional task.

Subject Knowledge Important

It is true, however, that a knowledge of the product or subject is important to a writer or editor. He cannot do a satisfactory job if he isolates himself completely from the engineer and the hardware. Yet, in his role of representing the reader, he need not know every detail known to the engineer; in fact, too much specialized knowledge of details may prove to be a handicap. At the Martin Company, our editors obtain this degree of first-hand product knowledge by working in the same physical location as do the engineers on a project, by attending project meetings, and by field trips to inspect customer activities.

What and Who?

What, then, are the best sources of technical writers and editors? Who can satisfactorily fill the editorial positions found in industry?

First of all, we must not discount the value of honest-to-goodness editors who have engineering degrees. But they should be engineers who have elected to study the written and spoken language and who are more interested in communicating by words and other publishing devices than by purely technical means only. Such training can be accomplished in a five-year undergraduate program and, to some extent, in the general engineering programs which have liberal policies on elective courses. If they do not have the benefit of military training, liberal arts majors who want to become technical editors should take a carefully chosen group of engineering and science electives.

A Utopian solution proposed by C. K. Arnold (5) is to establish a new curriculum that includes "basic training in the tools of both the editor and the scientist. . . ." Such a program might be administered either in engineering, or in a liberal arts or science department with the close cooperation of the engineering faculty.

Yet it is doubtful if the universities will add a new program of this type until (a) industry convinces them that there is a continuing demand for technical editors and (b) high school students, teachers and vocational counsellors, becoming fully aware of the opportunities, provide the required number and type of students. Further, it is possible to modify existing technical journalism programs to achieve the same objectives as the curriculum proposed by Mr. Arnold. Iowa State, for example, offers a minor sequence in journalism for engineers and an M.S. degree in engineering journalism.

To date, however, technical journalism programs have been slanted mainly toward the technical press and industrial advertising. These curric-

ula are almost evenly divided among three groups of subjects: (a) technical journalism, English, and other "communications" subjects; (b) specified physical and social sciences; and (c) electives or options.

These programs would also be useful in training technical editors if the electives were taken in engineering and if some of the journalism courses specifically took into account the more recently determined needs of industry. Typical programs that would be satsifactory are science journalism as offered at Iowa State and technical journalism as offered at Kansas State. These programs can provide not only basic editorial training, but sound schooling in the physical sciences and engineering—as well as a good knowledge of the social sciences. The latter is particularly helpful in compensating for the weaknesses of typical engineering personnel.

To get full value from these sources, industry and the universities should get together (a) to establish more clearly the requirements of industry; (b) to make the opportunities known to high school students; and (c) to determine the personal qualifications that make for success in this unusual combination of a science and an art.

BIBLIOGRAPHY

(1) Robert T. Hamlett, "New Horizons in Technical Writing." Panel Discussion at Technical Writers' Institute, Rensselaer Polytechnic Institute, June, 1955.

(2) H. C. McDaniel and C. A. Scarlott, "Technical Writing Opportunities for Engineering Graduates." *Journal of College Placement*, May, 1954.

(3) Sterling P. Olmsted, "A Graduate Curriculum in Technical Writing." *Journal of Engineering Education*, March, 1955.

(4) Dwight E. Gray, "Editing Technical Reports." *The Production and Use of Technical Reports*. The Catholic University of America Press, Washington, D. C., 1955.

(5) Christian K. Arnold. "A Curriculum for Technical Editors." *Journal of Engineering Education*, November, 1954.

EJC PROCEEDINGS

Discussions of the Reserve Forces Act of 1955, the balanced use of engineers and technicians, and the findings of the Hoover Commission are highlights of the material compiled in *Proceedings —Second General Assembly* of the Engineers Joint Council. The 68-page pamphlet contains not only the formal talks at the EJC General Council held in New York, January 26 and 27, 1956, but also reports the questions and discussions from the floor during the two-day conference. Details of the program are available in the December, 1955, issue of the JOURNAL OF ENGINEERING EDUCATION, page 412. The major issues and problems covered are of interest to the engineering profession today. The summary can be obtained from the EJC, 29 West 39th Street, New York, New York, for $1.00.

WHY DO ENGINEERS DISLIKE TECHNICAL WRITING?

H. M. FRIEND

Formerly with Technical Publications
Bell Aircraft Corporation
Buffalo, New York

Retired; present address Route 2, Box 646, Theodore, Alabama

Why do engineers who produce such outstanding technical work do a poor job when writing about it? There are many theories; one says it is the fault of engineering education, another that the engineer himself has a bad psychological attitude toward writing.

This subject was discussed with engineers who do technical writing, and engineering executives were asked their opinions through a questionnaire.

The engineers who wrote generally said they didn't like to do so. Their reasons were varied, but in main were that they considered writing "busy work" of little importance, had never been properly trained in writing and found it confusing, and, accustomed to dealing with tangibles, found words and thoughts abstractions difficult to handle.

Engineering executives were chosen from both business and education. They all felt engineering writing was poor and agreed that engineering education did little in encouraging a student to write more effectively. Most executives questioned said technical writing comes hard because it is, in a sense, anticlimactic. Coming as it does after a project is finished, the engineer is impatient with writing up a past project and wants to get started on another problem.

A few executives mentioned that engineers are attracted to engineering in the first place because they have aptitudes in science and mathematics, and little liking for English. They can't see where writing proficiency will help them much in their chosen work, either.

A few men agreed technical writing was doubly difficult because the precise and constricted style necessary for accuracy is very boring. One man mentioned that companies employing engineers usually minimize the importance of technical writing. The majority of employees, he says, show actual contempt for "pencil pushing" and thus indoctrinate the already prejudiced engineer against technical writing.

In conclusion, it can be seen that the engineer's psychological barrier against technical writing must be removed before any improvement can be hoped for in his product. This can be done first of all in schools by offering courses in writing that stress how

interesting expressing yourself can be. If a student likes to write in the first place, professional and technical composition will come much more easily for him. Also, companies should realize the importance of well-written technical material and encourage in this direction, with praise and advancement, any employees who have training or aptitude for expression.

CIVIL ENGINEERING DIVISION-A. G. C. JOINT COOPERATIVE COMMITTEE

Following approval last November by the Executive Board and the General Council of the Society, the Association of General Contractors and the ASEE Civil Engineering Division have established a joint cooperative committee to consider problems of mutual interest. The first meeting will be held in the Memorial Union Building at Iowa State College, Ames, June 30, 1956. Typical problems scheduled for possible consideration are student and faculty summer employment, scholarship awards from industry, and methods to increase the supply of science teachers. Members of the committee are:

Acting Co-Chairmen

ASEE	A.G.C.
Frank W. Stubbs	W. A. Klinger

Acting Co-Secretaries

R. L. Peurifoy	Archie N. Carter

Committee Members

Paul F. Keim	Walter L. Couse
Arthur J. McNair	Arthur S. Horner
C. H. Oglesby	Manley Osgood
Harry Rubey	Howard H. Sturdy
W. W. Schenler	D. W. Winkelman

MICROWAVE ENGINEERING: HOW A NEW COURSE IS ADOPTED

CHARLES SÜSSKIND

Assistant Professor of Electrical Engineering
University of California, Berkeley

The following observations are based on the results of a survey conducted by the writer during 1954–1955 with a view to establishing the scope of college-level instruction in microwave (ultra-high-frequency) engineering, and making an estimate of the rate at which this important new subject has been entering the curricula of American engineering schools.

The survey was the outgrowth of an earlier one,[1] in which graduate curricula in electrical engineering were reviewed and certain educational trends were noted. In the earlier survey, some thirty electrical-engineering topics were listed by the various institutions as fields of specialization, but the answers could not be readily interpreted to provide any information regarding the degree of specialization or the development of the several subjects.

In the present survey, an attempt to obtain such information in a statistically significant form was made by selecting one of these subjects and making a detailed inquiry into its history and present status in engineering education. Many of the findings can be doubtless extended to apply to any engineering specialty, so that this procedure may be considered to be equivalent to a poll of a representative "sample" of engineering institutions. The subject selected for this particular sampling, microwave engineering, was picked partly because of the author's personal interest in it, but also because it represents a fairly new field—and yet one that has been with us long enough to become firmly established in the curriculum.

[1] G. R. Arthur and C. Süsskind, "Report on Graduate Curricula," *Proc. Inst. Rad. Eng.* **41**: 1952–3 (1953).

Institutions Polled

Questionnaires asking for information regarding courses and enrollments in the pertinent subjects, laboratory facilities, and textbooks prescribed or recommended, were sent to 152 institutions offering degrees in electrical engineering, of which 135 have curricula approved by the Engineers Council for Professional Development (ECPD). Fully 147, or 97 per cent, returned the filled-in questionnaires. A preliminary evaluation quickly showed that from the viewpoint of instruction in microwave engineering, each reporting institution could be readily assigned to one of three groups:

GROUP I: Several courses specifically devoted to microwaves, making up a considerable portion of the total electrical-engineering program. 10 institutions: Brooklyn Polytechnic Institute, California, Illinois Tech, Illinois, M.I.T., Michigan, Northwestern, Ohio State, Stanford, and Yale.

GROUP II: One or two microwave courses, usually with small enrollments, and constituting a relatively small portion of the over-all program.

62 institutions: Akron, Alabama Poly, Arizona, Arkansas, Brown, Buffalo, C.C.N.Y., Caltech, Cal. Poly, Cincinnati, Clarkson Tech, Colorado A. & M., Connecticut, Cornell, Dayton, Delaware, Drexel Tech, Fenn, Florida, Harvard, Iowa State, Iowa, Johns Hopkins, Kansas, Kentucky, Lafayette, Louisiana State, Loyola (L.A.), Maryland, Michigan M. & T., Michigan State, Milwaukee, Minnesota, Mississippi State, Missouri Mines, Missouri, Montana, New Mexico A. & M., New Mexico, Newark, North Dakota, Northeastern, Notre Dame, Ohio U., Oklahoma A. & M., Oklahoma, Pennsylvania Mil. Coll., Penn State, Princeton, Rensselaer, Seattle, U.S.C., Texas A. & M., Toledo, Tufts, Utah State, Utah, Villanova, Virginia Poly, Virginia, Washington, and Wisconsin.

GROUP III: No courses devoted entirely to microwaves. 75 institutions.

No Special Courses at Most Schools

The size of Group III is one of the more interesting results of the survey: more than half of the electrical-engineering departments in America have scheduled no courses comprising exclusively topics in microwave engineering. (This group includes, however, 11 of the 17 reporting institutions with curricula not approved by ECPD.) About half a dozen are planning to offer such a course within a year or two, and a few belong to universities at which sizable microwave programs are being carried on by the physics department (e.g., Alabama and Duke).

Virtually every school in this group has a place for microwave topics somewhere in its curriculum. According to replies to one part of the questionnaire, more than half teach the subject as a "predominant part of one or more electronics courses," either on the undergraduate or graduate level; most of the others teach microwaves as a "minor part of one or more electronics courses," and only a handful "not at all." There is some evidence, from replies to a question inviting comments, that several of the EE departments in Group III have deliberately avoided setting up a separate microwave-engineering course. The comments, which range in tone from apologetic to irascible (". . . do not approve such a division on a frequency basis—poor way to teach . . ."), make it obvious that not all the institutions in Group III are in this group solely because of a lack of facilities or qualified teaching personnel, although this appears to be the case for most of them.

Degree of Specialization

The remaining schools (Groups I and II) appear not only to have recognized the various advantages of teaching microwave engineering as a separate subject but—what is perhaps more important—were able to achieve this separation by virtue of superior facilities and larger budgets. It is certainly no coincidence that Groups I and II include a far greater number of the larger engineering colleges than Group III, which consists predominantly of smaller and less well-established institutions. The size and total endowment of the institution are not always the significant factors in this respect, to be sure; but the replies to a question asking for an estimate of the dollar worth of test equipment used in the instruction laboratories for (a) general electronics and (b) microwaves actually show that the EE departments of the schools in Groups I and II are on the whole

much better endowed than those in Group III.

Nevertheless, whether an institution falls into Group I or II does not appear to depend on size alone (though all schools in Group I have large enrollments and very good engineering facilities), but rather on several other factors that may or may not be the corollaries of large size, such as the availability of faculty members who have the training and the inclination to specialize in the particular subject, the extent of sponsored research in the department and elsewhere in the institution, and the history of the department (i.e., how soon the subject was established). A comparison of the institutions in the top group with those in Group II suggests strongly that the development of a highly specialized program in microwave engineering (and, by inference, in any other specialty) can be related to factors such as the above, and hence may be influenced to a considerable extent by departmental policy on employment, soliciting of research funds, and adjusting curricula to new demands.

The higher degree of specialization does not manifest itself solely in the larger number of courses devoted to the subject, but also in the manner in which the subject is taught. The present survey sought to obtain a measure of instructional sophistication by listing 10 textbooks on microwave theory and measurements and asking which of these (or any other) books are prescribed or used as references at each school. The same three standard textbooks (Brownwell and Beam, *Theory and Application of Microwaves;* Ramo and Whinnery, *Fields and Waves in Modern Radio;* and Reich, Krauss, Ordung, and Skalnik, *Microwave Theory and Techniques*)

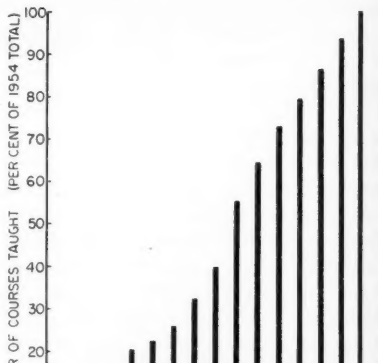


FIG. 1. Total number of courses in microwave engineering taught at Group I and II institutions, with 1954–55 as 100 per cent.

are most frequently prescribed at schools in both Group I and II, but the more advanced works, such as Montgomery's *Principles of Microwave Circuits* and Slater's *Microwave Electronics,* are more frequently prescribed *or* recommended in Group I institutions.

Rate of Adoption

Replies to the questionnaires did not yield reliable information as to which school in America was the first to schedule a formal course devoted to ultra-high frequencies, particularly since not all of the reporting institutions were in a position to state when each course was first given. The subject was doubtless taught as part of other courses very soon after oscillators in this frequency range first became available, in the late 'thirties. The first date to appear in the ques-

tionnaires is 1939, several years before microwave engineering could have been said to constitute a significant part of the technology. The most reliable measure of the rate at which the various institutions have been adopting microwave engineering as a separate subject since then may be obtained by tabulating the total (aggregate) number of courses taught in any given year. This information, based on starting dates for over 100 courses now being taught at Group I and II schools, is plotted in Figure 1, normalized to 1954–1955 as 100%.

It can be seen that adoption got off to a slow start, probably owing to military restrictions on the subject during the war years, 1939–1945, when most new work in it was being done at special industrial or government-sponsored laboratories rather than in engineering colleges. Since then, the total number of courses being given has climbed at a steady rate, and shows no sign of leveling off even after ten years. A further breakdown shows no significant difference in the rate of adoption between institutions in Groups I and II, although this finding cannot be considered to be wholly conclusive because of the small size of Group I (10 institutions).

One conclusion is incontrovertible, however: our engineering colleges are very much alive to the challenge of a changing technology. A new topic, such as microwave engineering, has every chance of being included in the curriculum as fast as the demand arises. In fact, the results of the present survey indicate that engineering schools sometimes anticipate the demand and actually provide instruction in a new field even before it has had time to develop technologically, thus fulfilling their exalted function of leading in the progress of our civilization, rather than merely following the lead of others.

ON TEACHING PHYSICAL MECHANICS

RAYMOND J. SEEGER

Assistant Director (Acting)
National Science Foundation
Washington 25, D. C.

Based on a paper given at the joint meeting of the American Society of Engineering Education (Physics Division) and of the American Association of Physics Teachers at Pennsylvania State University, June, 1955.

As a college student I took a mathematics course called "Analytical Mechanics." Such a title, I suppose, suggests an emphasis on an algebraic approach to mechanics somewhat in the tradition of L. Euler's "Mechanica, sive Motus Scientia Analytice Exposita" (1736) and of J. Lagrange's "Mécanique Analytique" (1788), as contrasted with the synthetical (geometrical) approach in I. Newton's "Philosophiae Naturalis Principia Mathematica" (1686). You may recall that Lagrange even boasted in his preface that "there are no figures in this work." Who among us, indeed, has not experienced a thrill in realizing the beauty of theoretical mechanics and the power of its analytic techniques! Mechanics, including celestial mechanics, is both the oldest and the most highly developed of the physical sciences—one of man's great intellectual achievements.

Physical mechanics,[1] as I use the term, is not this analytical (or rational) mechanics [2] as understood by the mathematician, nor is it applied mechanics [3] as used by the engineer (although I would certainly illustrate physical principles to some degree with concrete applications from engineering, as well as from astronomy and physics). It is interesting to compare J. L. Synge's [4] definition of mathematical physics: "The creation of a coherent mathematical theory with assumptions clearly set forth is the primary object, physical interpretation in terms of experiment being relegated to a secondary position." I would argue that this type of course might better be termed applied mathematics. It is certainly not physics, which must always be rooted in phenomena. His other category termed "naturalistic physics" seems etymologically confusing, but more akin to my concept of physical mechanics. In his lectures on "Partial Differential Equations in

[1] M. Born, "Experiment and Theory in Physics" (1943). A. Einstein, "On the Method of Theoretical Physics" (1933). P. Frank, "Philosophy of Science" (unpublished notes 1955). R. B. Lindsay and H. Margenau, "Foundations of Physics" (1936). E. Mach, "System of Mechanics" (5th Eng. ed., 1942). A. Sommerfeld, "Mechanics" (Eng. ed., 1952).

[2] P. Appell, "Traité de Mécanique Rationnelle" (5th ed., 1926). W. W. Osgood, "Mechanics" (1933). E. T. Whittaker, "Analytical Dynamics" (4th ed., 1937).

[3] H. F. Girvin, "A Historical Appraisal of Mechanics" (1948). G. W. Housner and D. E. Hudson, "Applied Mechanics" (1950). J. L. Meriam, "Mechanics" (1952). A. P. Poorman, "Applied Mechanics" (4th ed., 1940). J. L. Singer, "Engineering Mechanics" (2nd ed., 1954).

[4] J. L. Synge, "Geometrical Mechanics and de Broglie Waves" (1952).

Physics" A. Sommerfeld notes: "We do not really deal with mathematical physics, but with physical mathematics; not with the mathematical formulation of physical facts, but with the physical motivation of mathematical methods." M. Born properly concludes his "Experiment and Theory in Physics" as follows: "My advice to those who wish to learn the art of scientific prophecy is not to rely on abstract reason, but to decipher the secret language of Nature from Nature's documents, the facts of experience." From the viewpoint that physics is essentially the creative product of a physicist, physical mechanics stresses the critical understanding of mechanical phenomena by the scientific method, including the limits to which its successes can be extended to other phenomena. Through necessarily slow social acceptance, the science of yesterday becomes the common sense of today and, as such, appears to be self evident. First courses in mechanics, accordingly, are peculiarly susceptible of being taught from a dogmatic and over-simplified point of view. The present theories of motion, on the contrary, have not always been accepted. As late as 1915 even E. Mach remarked, "I do not consider Newtonian principles a completed and perfected thing." One must recognize the challenging frontiers of yesterday in order to be alert to the challenges inherent in the obvious of today. For example, the equivalence of gravitational mass and of inertial mass was regarded by many as a happy coincidence until A. Einstein saw in this fact a fundamental relationship between gravitation and matter.

In approaching physical mechanics as an endless frontier of research and education,[5] therefore, I would emphasize: (a) an operational[6] point of view with respect to the world of (classical) mechanical phenomena; (b) the physical use of mathematics[7] with respect to the world of mathematical concepts; and (c) the mechanistic philosophy[8] of matter with respect to the world of physical theory.

Let us consider, first, the operational point of view with respect to the world of mechanical phenomena (less valuable in atomic phenomena where physical quantities are not

[5] R. J. Seeger, "On Fluid Dynamics in Physics Teaching," *Amer. Journal of Physics, 21,* 29 (1953); "On Education, Engineering and Physics," JOURNAL OF ENG. EDUCATION, *44,* 285–80 (1954); "Physics Is Not Engineering," JOURNAL OF ENG. EDUCATION, *46,* 127 (1955); "On the Liberal Sciences," *Journal of The Washington Academy of Sciences, 45,* 361 (1955).

[6] P. W. Bridgman, "The Logic of Modern Physics" (1928); "The Nature of Physical Theory" (1936); "The Nature of Some of Our Physical Concepts" (1952). H. Poincaré, "The Foundations of Science" (Eng. ed., 1913). R. J. Seeger, "Beyond Operationalism" (*The Scientific Monthly, 79,* 226–27, 1954).

[7] M. Black, "The Nature of Mathematics" (1933). R. Courant and H. Robbins, "What Is Mathematics?" (1941). R. Courant and D. Hilbert, "Methods of Mathematical Methods" I (Eng. ed., 1953). A. Sommerfeld, "Partial Differential Equations in Physics" (Eng. ed., 1948). A. N. Whitehead, "An Introduction to Mathematics" (1911).

[8] E. A. Burtt, "The Metaphysical Foundations of Modern Physical Science" (Rev. ed., 1932). H. Butterfield, "The Origins of Modern Science" (1951). L. de Broglie, "Physics and Microphysics" (Eng. ed., 1955). H. Dingle, "Through Science to Philosophy" (1937). A. Einstein and L. Infeld, "The Evolution of Physics" (1938). G. Gamow, "Mr. Tompkins in Wonderland" (1940); "Mr. Tompkins Explores the Atom." J. C. Slater, "Modern Physics" (1955). R. von Mises, "Positivism" (1951). A. N. Whitehead, "Science and the Modern World" (1928).

accessible to direct measurement). Any physics course, I would again urge, must be kept intimately related to observations, particularly quantitative ones. In making measurements we are at once confronted with three primitive concepts, *viz.*, length, time, and mass.

The student should be introduced to the range of values for these quantities actually measurable in nature, viz., distances from $(10)^{-13}$ cm. for a nuclear radius to $(10)^{27}$ cm. for the distance to the farthest galaxy, times from $(10)^{-10}$ sec. for a nuclear lifetime to $(10)^{11}$ sec. duration between known ecliptic measurements to $(10)^{16}$ sec. for estimated age of the universe; masses from $(10)^{-27}$ g. for an electron at rest to $(10)^{35}$ g. for a star. He should be encouraged to wonder at these particular values and to have some appreciation of the different techniques employed to cover these gamuts.

Take first the concept of length. I am using this term not as an *a priori* category, but rather as an experience in physical or public space—not in private or individual space, nor in mathematical or conceptual space. What do we mean by the length of a familiar object, say, the length of an iron rod? Let us measure it in terms of some arbitrary unit. Evidently the answer we obtain depends upon the physical conditions of the rod at the time of measurement: its temperature, the gravitational field, the electric field, the magnetic field, *et al.* All that we mean physically by the length of such a body, then, is the answer we get in following certain prescribed procedures of measurement under specific physical conditions. The procedures, moreover, may be quite different, as in the case of a length like the distance from the earth to the moon. To determine the distance to the moon one employs essentially the method of triangulation familiarly used with a surveyor's theodolite. Because of the inaccessibility of the moon, however, we must supplement direct observations with some theoretical interpretations. For example, the calculations depend upon the optical laws involved in the propagation of light and upon the geometrical theorems applied. This method of length measurement, therefore, is operationally different from the one previously used. What about the resulting concept of length? Is it the same in each instance? Let us regard still another case, say, the diameter of an electron? Here we not only have no method of direct observation, but we cannot even see the object. Our method of measurement, therefore, is still more indirect. Now we have to rely on the use of electromagnetic theory with its complicated effects for high-speed motion. Hence we have distinctly a third operational procedure. Strictly speaking, these three different methods of measurement imply three different concepts of length. It is only because of their equivalence under the same limiting conditions that we are justified in postulating a common concept of length. It is not that the length of any body ever changes but rather that different methods of measurement may be used so that one seeks to obtain a value for the length satisfactory for all (the restricted theory of relativity postulates this invariance for systems moving uniformly relative to each other).

It can be shown that the postulate of the constancy of the speed of light in vacuo for systems moving uniformly relative to each other demands

that the measured length of a rod moving lengthwise be less than that of the rod at rest. Hence in relativistic mechanics a rigid body takes on different characteristics which can no longer be described by ordinary Euclidean geometry. For example, the ratio of the circumference of a uniformly rotating disc to its radius is equal to 2π only for a small radius, where the linear speed is small with respect to the speed of light, so that a disc cannot generally be regarded as a Euclidean rigid body in the classical mechanical sense. By assuming non-Euclidean axioms, however, we can make a new definition of a rigid body which reduces to the familiar one for small speeds (i.e., in the limit for zero speed).

We find a similar problem presented to us in the case of time. Even the seemingly self-evident concept of simultaneity is found to be fraught with difficulties which stem from the finite, constant speed of light which is found to be independent of the relative motion of observed and observer. Just as rods appear to be shorter if measured when moving than when at rest, so clocks seem to be slower when moving as compared with their readings when at rest. Thus even obvious concepts like time and length need to be examined carefully from a modern operational point of view.

We recall, moreover, that ever since the day of Descartes, who reduced Aristotle's primary qualities to extension in space and duration in time, description of matter and motion has been formulated in these terms, together with the concept of mass, which is involved in the fundamental laws of motion.

Newton's laws of motion have been regarded by some as conceptual definitions and by others as experimental facts. In view of the complex nature of modern theory, it is probably preferable to regard them somewhat like axioms in geometry (as an earth science) and to speak of them as principles of motion. The impracticability of giving direct descriptions of observed phenomena today necessitates such a formal (axiomatic) system with indirect descriptions. The laws of motion are to be regarded then as essentially free creations of man's mind; they are not uniquely determined by the world of phenomena. From these axioms, of course, one can make formal deductions in accordance with logical rigor—what might be properly called analytical mechanics. It is evident, however, that such a process would be physically meaningless without some relations between the ideal concepts and the actual phenomena; i.e., without operational significance. From this point of view let us consider each of the laws of motion.

Galileo arrived at his conception of inertia by watching the motion of a ball on a smooth, inclined plane. When the plane was inclined upward, the ball would stop; when it was inclined downward, the ball would accelerate. It was natural to suppose that for an infinite, horizontal (normal to the earth's gravitational field) plane without friction the ball would continue to move without a change in velocity. It was actually Newton who first formulated the generalization of this experience as we know it today. The first law of motion is not insignificant as some have supposed; rather it is actually the most fundamental and, hence, rightly first. The law appears simple; but it is quite complex. It states: "Every material body remains in a state of rest or of uniform

rectilinear motion unless compelled by forces acting on it to change its state." In a current popular text on applied mechanics, we read this interpretation of the law: "We define force by Newton's first law as an action which tends to change the motion of a body." This anthropomorphic conception of force is typical of the attitude found in many engineering texts. A physicist would certainly object at once to any such negative statement being a positive definition. This first law may well describe vaguely a state without force; this fact, however, does not enable one to characterize precisely a state with force. Newton's own statement, indeed, is physically meaningless without specifying just how one recognizes an unbalanced force, or rectilinear motion, or even a state of rest. In other words, this statement of the law is predicated upon a physical system of reference. Is the earth such a proper system? J. L. Foucault's pendulum experiment showed that the earth is changing its position relative to that of the pendulum, and hence to the fixed stars. How about the fixed stars themselves? Would they serve as a physical system of reference? Here, too, we now recognize proper motions even in "fixed" constellations. Strictly speaking, we can regard the earth as a system of reference in a first approximation; the fixed stars as such a system in a second approximation, etc. In this way we may define an ideal "inertial system," which represents an arbitrary formal (logical) convention, and which, in turn, will be practically useful only if it can be identified operationally. The law of inertia itself, however, does not tell us how to identify such an inertial system.

Newton's second law of motion states that "The change in motion [momentum] is proportional to the force acting and takes place in the direction of the straight line along which the force acts." In the above-quoted text one finds this interpretation: "The concept of force is made quantitatively precise by the definition that a unit force produces unit acceleration of a specified standard body . . . the mass of a body may now be defined by Newton's second law as the ratio of the force acting on the body to the resultant acceleration." It is evident in any case that a single relationship between force and mass cannot be used quantitatively for the definitions of both. One can express the so-called law of acceleration by the following equations.

$$F = km\,a,$$

or

$$F = ma, \text{ for } k = 1,$$

where F signifies the unbalanced force, m the mass of the body (or system), a its acceleration, and k a constant of proportionality. This form of the law is restricted to constancy of mass; the more general statement involves time-rate of change of momentum. We note that an inertial system is required here, too, for the operational specification of acceleration (i.e., acceleration with respect to what body or system?). If one can measure all three quantities independently, one then has an experimental law. It was first suggested by G. Kirchhoff that force should be regarded as merely a name for *ma;* it was later emphasized by H. Poincaré that this definition itself is purely a conventional matter. In any case the statement is physically meaningless without an operational definition of force, too.

For a constant force, one finds the well-known formula that $s = \frac{1}{2} gt^2$ for the distance s traversed by a body starting initially from rest at some point in a uniform gravitation field chosen as the origin (g is the acceleration due to gravity). If the gravitational force on a body varies inversely as the square of its distance from a fixed point of attraction we find that the orbit is elliptic. Newton's law, of course, can be applied also to electric and magnetic forces. In any case, the path of motion is determined by integrating the equation of motion, which is all important. In general, by specifying the force F as a function of the coordinates, Newton's second law gives the acceleration of a body "simply" with respect to the coordinates, i.e., for a given inertial system. The structural content of the second law, therefore, is not specifically $F = ma$ (or generally $F = d/dt(mv)$), but rather the acceleration a as a function of the coordinates. Some individuals have spoken of a fourth law of motion (actually given as a corollary by Newton) in that each of several forces, acting simultaneously on the same body, is independent in causing the resultant effect, which can be determined for all by vector addition. For zero acceleration, of course, one obtains the well-known principle of conservation of momentum by integration with respect to the time. The principle of conservation of mechanical energy, in turn, follows from spatial integration of the general equation.

"Action always equals reaction" is the simple, but easily misunderstood, statement of Newton's third law of motion. Specifically, it means that the acceleration of a body does not occur alone in nature, but always in association with the acceleration of at least one other body—action of one body on another body and the reaction of the latter on the former. (This law, accordingly, determines the entire field of structural statics—rarely mentioned in engineering texts.) Let us examine its general significance.

First of all, it is the third law that makes possible an operational definition of mass—not the second law. For example, in the case of two bodies acting upon each other, one observes that the ratio of their acceleration is constant, independent of the force involved or of the velocities of the bodies, *et al.* This constant may be expressed as the ratio of two other constants, each of which is peculiar to its respective body, and which, therefore, may be regarded as its mass (determined uniquely for an arbitrary "standard" mass). This mass is independent of external circumstances; it may be regarded as a measure of the body's inertia. The product of the mass and acceleration, on the other hand, is independent of the body itself and thus may be looked upon as a measure of the external force on it. The operational definition of mass together with this operational definition of force (ma in terms of the coordinates), and with the operational definition of acceleration, makes the formal statement of the second law actually descriptive of mechanical phenomena and hence truly a physical law of nature.

The physics of the problem consists primarily in the formulation of the equation, including some mathematical guessing, and in the recognition of appropriate conditions to be satisfied by the solution—the rest is technical mathematics. One must be careful to distinguish physical essence from various modes of mathematical rep-

resentation. The number of specific physical conditions must equal the number of such arbitrary quantities for a real physical solution to the problem.

Secondly, if one considers large velocities, one finds it convenient to express the second law as an increment of the speed Δv proportional to the increment of time Δt involved thus:

$$\Delta v = (F/m)\,\Delta t.$$

For constant force F the speed v would increase without limit, which is contradictory to the principle of restricted relativity. In this case, therefore, the ratio of force to mass must simultaneously decrease in order that the speed v remain always less than the speed of light. In other words, the measured mass cannot be constant; it must necessarily increase with speed—and is actually observed to do so. Here we are likely to be confused by our own naiveté that mass is a measure of quantity of matter. We need a new operational definition of mass, which will agree with the older, simpler concept for small velocities, the latter mass being usually called the "rest mass" m_0 for the limit of zero speed. What is more, the ratio of the force on a body to its acceleration is observed to vary with the relative directions of the force and of the velocity of the body: for example, the measurement of the force transverse to the motion of a body is different from that obtained parallel to it. The vector sum (mv) of all momenta for interactions within a system is found to remain constant only for the transverse measurement, provided there are no external influences. Accordingly, in order to preserve the principle of conservation of momentum, one chooses now the transverse measurement F/a as a new operational definition of mass. This new mass, called the "apparent" or "relativistic" mass, is related to the rest mass as follows, for v is small relative to c:

$$m = m_0 + \frac{\text{Kinetic Energy}}{c^2},$$

where c is the speed of light. Because of its relation to the original ratio $m = F/a$, the relativistic mass can be regarded as a possible successor to Newtonian constant mass m_0. If we observe uranium fission, however, we observe an increase of the kinetic energy of the nuclear fragments with a corresponding decrease of the total rest masses—the sum of the apparent masses remaining constant (principle of conservation of mass). Hence we find ourselves now preferring relativistic mass as a new operational definition inasmuch as more theorems of Newtonian mechanics will be unaffected by this choice.

The idea of a system with variable mass, to be sure, is not restricted to relativistic considerations. In the previously cited text one reads, "It is important to note that Newton's second law refers to a specific body and does not refer directly to a system which is losing or gaining material." This statement itself is somewhat loose in more ways than one. In the first place, is one thinking of a rigid body or of a deformable body? Secondly, let us consider a system like a sprinkler wagon or an interplanetary rocket with continuous exhaust. In applying Newton's second law we can either add to the change in momentun contained in the body the momentum convectively added or given off per unit time, or we can regard the recoil

momentum gained or lost per unit time as a kind of external force. In either case, the second law of motion will certainly be applicable to this system losing (or gaining) material; the mathematical terms, however, have to be interpreted physically.

Inertial systems as now understood refer to systems moving uniformly relative to each other, for which Newtonian mechanics holds in its relativistic (restricted) form. The problem of formulating physical laws for every coordinate system has been solved by the theory of general relativity. The fact that inertial mass and gravitational mass are equal is here regarded as fundamental—not accidental as in classical mechanics. It would take us too far afield to develop this concept here. Suffice it to indicate the connection in an idealized experiment with an elevator. From the top of a super-skyscraper the supporting cable of an elevator breaks—unknown to the occupants, who are observing that a freely "falling" ball and pen behave in accord with the principle of inertia. To an outsider looking through a window the phenomena are also in agreement with Newtonian motion in a gravitational field. The equivalence of gravitational and inertial mass makes possible two different but consistent descriptions of the same phenomena for two systems that are not moving uniformly with respect to each other. Let us consider another idealized experiment, say, a cable lifting the elevator with constant force and hence constant acceleration. The ignorant observer inside would probably ascribe the "falling" of all bodies to the elevator's floor to a gravitational field, whereas, the outside observer would describe the same phenomenon as due solely to inertial behavior independent of any gravitational force. Einstein's principle of equivalence demands that every motion relative to an accelerated system behaves like a motion relative to an inertial system in a gravitational field. As in Newtonian relativistic mechanics there is no absolute speed (and hence translation), so in Einsteinian general relativity there is no absolute acceleration (and hence rotation). A pure field physics, however, is still unattained. Physical mechanics must continue to differentiate generally between matter and field. A physics student, at any rate, must learn early how the laws of mechanics are modified by relativity, which arises from field problems.

Let us now turn our attention to the world of mathematical concepts. We should always bear in mind that much of mathematics analysis has been invented specifically for describing physical phenomena: for example, the use of certain infinite series to solve practical problems in heat conduction. J. B. Fourier himself said, "Profound study of nature is the most fertile source of mathematical discoveries." The physicist has found it profitable not merely to watch the totality of phenomena like the moving water of a river, but rather to examine causally the behavior of very small portions for very short periods of time. Thus he sets up differential equations involving rates of change and then solves (integrates) them as functions of the time for comparison with the phenomena themselves.

The physicist is concerned primarily with the formulation of the physical problem in mathematical terms; the mathematician is responsible for interpreting the mathematical significance of the resulting equations. The differ-

ential equation by itself expresses only the general law for a physical phenomenon. A specific physical problem requires also initial or boundary conditions, which determine the arbitrary constants or functions that occur in the integration of the differential equation.

In the case of so-called ordinary differential equations, involving ordinary derivatives of a single independent variable, one considers generally a system with a finite number of degrees of freedom and with time as the single independent variable—for example, a single ideal system like a particle or a rigid body. The use of the derivative in describing the motion of such an object is based upon the assumption that the limit of the quotient of small increments of physical variables exists, which, in turn, is predicated upon the idea of a continuous function, for example, velocity $Lim_{\Delta t \to 0} \Delta s/\Delta t$. Position and velocity, however, are not sufficient to describe the motion of a body completely; as we have noted in Newton's laws, acceleration is also needed. This second-order derivative, moreover, has been found adequate so that higher time-derivatives are not required. Hence the equations of motion are second-order differential equations in time. A good illustration is so-called simple harmonic motion, as in the case of a spring with a particle attached and with a restoring force given by Hooke's law, i.e., the force is proportional to the displacement of the particle from its position of equilibrium and directed toward that position. In our everyday world such motion finally ceases. Accordingly, we must add a damping term, which is found to be proportional to the velocity. Furthermore, the restoring force for an object like the ear drum may require the addition of another term quadratic in the displacement. Furthermore, a twisted fiber requires the addition also of a "hereditary" term. In general, an ordinary differential equation relates the behavior of a particle here to an influence there, i.e., widely separated events. Its solution gives the history of a material particle at some later place in terms of its characteristics here and now. Sometimes ordinary differential equations occur in physical problems (e.g., the bending of beams) as a degenerate mathematical form due to the neglect of all but one independent variable.

In partial differential equations, involving a function of several variables and its partial derivatives, one is concerned with a system with infinite degrees of freedom and with independent space and time variables—for example, a continuous medium. An introductory mechanics course, I believe, should deal with such systems of an infinite number of degrees of freedom [5] as well as with systems of a finite number of degrees of freedom. A partial differential equation describes the state of such a system "here and now" in terms of the immediate neighborhood just a little while ago. Its solution gives the history of the whole field later in terms of its characteristics all over now. Moreover, one uses field quantities, defined at such point-space as function of time; hence there are usually four independent variables for partial differential equations of physics. Here assuming that the physical quantities are continuous functions of the coordinates and of the time, by a Taylor expansion in the neighborhood of equilibrium and by neglect of higher-order terms, one finds as an expres-

sion of the principle of conservation of mass the so-called equation of continuity, a first-order partial differential equation. The further assumption of a velocity function for an incompressible, homogeneous medium results in the Laplace's second-order differential equation (spatial). Likewise the equation of motion reduces to a first-order partial differential equation. If one assumes also that the displacements, the corresponding velocities, and their rates of change are negligible to the extent that powers of them higher than the first are all relatively negligible, one obtains the well-known wave equation, a second-order partial differential equation in time and space. Its linear character signifies the principle of superposition of waves. It should be noted, however, that shock waves can be described without the assumption of continuity by a direct application of the conservation principles. They represent non-linear phenomena without any evident rule for superposition.

Whereas arbitrary constants expressing initial values are adequate for the complete solution of an ordinary differential equation, arbitrary functions are required for the general solution of a partial differential equation. (Differentiation enables one to eliminate particular constants and to obtain a more general description, whereas integration involves specific knowledge for describing actual physical phenomena.) A solution of a partial differential equation in variables is usually sought over some n-dimensional domain. Often conditions are imposed over an $(n-1)$ domain. For example, in the case of a typical "initial-value" problem with two variables the initial values of amplitude and velocity along an open curve must be specified at an initial time in order to obtain amplitudes and velocities for all future times (cf. wave phenomena). In the case of a typical "boundary-value" problem, however, values of the functions and its derivatives along a closed curve, independent of time, are required for determining the nature of a regular function within the curve (cf. equilibria phenomena). Fixed points on a vibrating string and quantum conditions behave virtually as boundary conditions in selecting particular functions, i.e., those with certain frequency values. Why in certain problems, however, does one need initial values and why in others boundary conditions? In general, one finds that these mathematical conditions are required in order that we may obtain a so-called reasonable solution, namely, one mathematically useful for interpreting a physical process. On the one hand, mathematics must not impose so many restrictions that no solution at all can satisfy them; on the other hand, the restrictions must not be so few that no unique solution is possible. Finally, the solution must depend upon data continuously, so that small data changes, inherent in necessarily approximate measurements, cannot produce large changes in the resulting solutions. The use of modern high-speed calculating machines for the numerical analysis of differential equations has introduced a new era for the physical use of mathematical concepts. Problems can be solved today which were impractical a generation ago.

One more note on the physical use of mathematics! It is highly desirable that a physical law should be independent of the particular coordinate system describing it. The physical quantities involved, therefore, must

transform in similar ways, i.e., they must be represented by tensors. Unfortunately tensors, which are represented by second degree surfaces (cf. the ellipsoid of inertia), are less concrete and, therefore, seemingly less intelligible than vectors, which represent line segments. Here again, we see that the general form of the law may be as important physically as its specific content.

Let us now consider the development of mechanistic philosophy with respect to the world of physical theory. In other words, what is the scope of theoretical mechanics and what is its limitation, particularly in the world of theoretical physics? Newton's laws of motion are remarkable in that they are still valuable in their original form (operationally interpreted) for describing mechanical phenomena—partially because their accuracy makes them useful, partially because their simplicity renders them teachable, and partially because their naturalness makes them socially acceptable (due to their close analogy with the very phenomena). It would be unfortunate, however, in a world of modern physics for students to be indoctrinated with the idea that Newton's laws of motion, which were formulated almost 300 years ago, are the last word even on the subject of mechanics itself. There have been more recent formulations of mechanics which have enabled man to deepen his understanding of the known relations. For example, in 1743 J. D'Alembert enunciated a principle by means of which dynamical phenomena can be treated from the standpoint of equilibrium, i.e., from the standpoint of statics. Using the concept of force he was able to express the laws of mechanical motion in a single formula with grace and elegance—a remarkable example of economy of thought. Subsequently, J. Lagrange derived equations for any physical system in terms of generalized coordinates, particularly valuable in cases of acoustical, optical, and electrical phenomena, where particles may not even be observable. Later W. R. Hamilton discovered a canonical form of the basic equations, which have the valuable property of remaining invariant with respect to certain theoretical types of coordinate transformation. It would seem desirable in any physics course to outline the historical perspective of mechanics from its primitive concepts to these more abstract ones.

More radical views, however, have been introduced by others. Starting with the intuitive principle of least action in 1747 by P. L. Moreau de Maupertuis, Hamilton introduced a more general one in 1824. He found it possible to describe mechanical phenomena in terms of the stationary values of an integral involving an energy function. This integral does not require a knowledge of the forces themselves; moreover, it is independent of the coordinate system employed. The principle is applicable to the classical mechanics not only of particles and of rigid bodies, but also of deformable bodies and fluids—not to mention field theories (electromagnetism, electron, proton, meson). The principle thus has a highly significant economic descriptive value in that it epitomizes so many different areas of phenomena. Another novel idea was introduced in 1829 by C. F. Gauss in his principle of least constraint. Here one requires the knowledge of neither force nor energy, only the criterion that the system should move as freely

as possible with respect to certain constraints that are necessitated because of the impressed forces. A more abstract generalization of this principle was made in 1894 by H. R. Hertz, who proposed a principle of straightest path. Avoiding the concepts of mass, force, and energy he succeeded in reducing dynamics to kinematics by means of certain concealed motions of particles. The system can thus be regarded as virtually in a state of rest or of uniform motion. Let us turn now from these abstract theories to concrete applications, particularly in other physical phenomena.

As emphasized by E. Mach, "Purely mechanical phenomena do not exist." They are "abstractions, made either intentionally or from necessity, facilitating our comprehension of things." A. Einstein has stressed that "it is impossible to divide science into separate and unrelated sections." Newton himself applied the laws of mechanics to the analysis of fluid motions, including acoustical phenomena. He was able to account for compression waves in fluids and solids. It is significant, indeed, that he believed the laws applicable to all motions, mechanical or otherwise.

In 1738 D. Bernoulli extended the realm of mechanics to account for the pressure in gases in terms of the motion of particles. It was J. P. Joule, however, who in 1851 related this molecular motion to the thermal energy of the gas. Subsequently, the kinetic theory of gases was further extended to explain phenomena such as viscosity in terms of transport of momentum, diffusion in terms of transport of matter, and heat conduction in terms of transport of energy. Statistical mechanics *per se* is undoubtedly beyond the scope of a course in physical mechanics. The general area of its scope and validity, however, should be pointed out to beginning students.

The conservation of mechanical energy is obtained from spatial integration of the equations of motion. In general, it is inadequate for a complete description of mechanical phenomena except in the case of a system with one degree of freedom, which has only one equation of motion. So-called conservative systems comprise a useful class for theoretical analysis of mechanical phenomena. In the case of non-conservative systems the realization that heat can be regarded as a mode of motion has made it possible for certain of these, in turn, to be described in mechanical terms. It is significant that such concepts as electrical energy, *et al.*, are operationally meaningless today except in mechanical terms. The success of mechanism in enabling one to understand any physical phenomenon was largely responsible for the belief of individuals like H. von Helmholtz and Lord Kelvin that no physical theory itself can be successful unless it has a mechanical basis.

Subsequently physicists have become more aware of the limitations of mechanism in theoretical physics. I shall not attempt to develop here the rise and decline of the mechanical view in the realm of electrical and optical phenomena—not properly physical mechanics. Suffice it to note certain aspects of modern particle physics. In the first place, although the position and velocity of molecules are determinable in principle, from a practical viewpoint there always exists an ignorance of initial values. Hence probability considerations and statistical methods must be introduced to

supplement the conservation of energy in thermodynamics with the so-called second law of thermodynamics, which is statistical in character (cf. Brownian movements from which the mass of a molecule can be determined).

The development of wave mechanics in quantum physics seemed at first likely to extend further the applicability of mechanics to physical phenomena. Here however, the ignorance of initial values presents a difficulty inherent in the very phenomena (cf. the uncertainty principle), because the simultaneous determination of position and velocity of a particle like an electron with increasing precision is not possible even in principle. Hence quantum mechanics itself has had to be interpreted statistically to preserve the law of causality for theoretical concepts and at the same time to relate them to the world of phenomena.

In nuclear physics, too, one learned early of the limitations of mechanics in describing phenomena like radioactivity. Here the number of particles emitted from nuclei is found to be proportional to the number of nuclei and to the duration of observation. The number, however, is observed to be independent of the velocity, the mass, the force, or the energy of the particles. Once more we are confronted with the necessity of introducing probability considerations. It is necessary to add that the whole question of the nature of elementary particles is becoming increasingly complex and confusing, not to mention their relation both to fields, and to the understanding of matter itself. In the face of these phenomena one wonders about the validity of the assertion in the above mentioned text that "All observations subsequent to Newton's time are in agreement with them" [Newton's Laws].

In conclusion, it is evident that physicists no longer require mechanical models for interpreting physical phenomena. Nevertheless, mechanics is still the foundation of all modern physics in the sense that its generalized principles such as the conservation of momentum, the conservation of mass or energy, and the principle of least action are still basic to physics. Hence physical mechanics needs to be taught in relation to all modern branches of physics and taught necessarily by physicists, who are intimately concerned with the new foundations of physics.

As a mathematical physicist, I would emphasize in such a course the operational point of view with respect to the world of physical phenomena, the physical use of mathematics with respect to the world of mathematical concepts, the scope and limitation of mechanistic philosophy with respect to the world of physical theory. In the tradition of natural philosophy the subject should be treated both experimentally and philosophically. From this point of view, therefore, analytical mechanics and applied mechanics, worthwhile in their own domains, could certainly not be identified with physical mechanics.

THE FUTURE SCIENTISTS OF AMERICA FOUNDATION

HENRY H. ARMSBY

Chief for Engineering Education
U. S. Office of Education
and ASEE representative on the Advisory Committee of FSAF

The Future Scientists of America Foundation (FSAF) was born four years ago out of the conviction on the part of a group of educational leaders that the best way to improve the long-range supply of engineers, scientists, and technicians is to increase the numbers of qualified boys and girls coming out of high school with adequate preparation for good college or technical institute work in these fields and interested in careers in one of these fields. The Foundation was formed only after extensive consultation with scientists and educators, and was organized as an activity of the National Science Teachers Association (NSTA). It operates under an Administrative Committee including representatives of the sciences, engineering, and education, and with the advice and counsel of an Advisory Committee representing industries and societies interested in the objectives of the Foundation.

Within six months after its establishment, enough money had been contributed by industries and the professional societies to add two full-time people to the NSTA staff and to launch the Foundation's program. An extensive survey was conducted among teachers, professional societies, and industrial organizations to determine current practices, problems, and gaps in the materials and services available for encouraging young people toward engineering, scientific, and technical careers. The results of this survey, published in 1953, identified the objectives and suggested procedures for the Foundation.

The Foundation seeks to secure for junior and senior high school science students and their teachers services comparable to those existing at college and post-graduate levels. The Foundation does not attempt to replace any agencies now active in the promotion of science and engineering, but rather to supplement and coordinate efforts so that there can be continuous assistance available from the elementary through the secondary school and the college up to and including post-graduate levels.

With this in mind, close relationships have been established with the Engineering Manpower Commission, the Scientific Manpower Commission, the Manufacturing Chemists Association, the National Science Foundation, the American Society for Engineering Education, and other organizations, and will be extended to other groups interested in the purposes of the Foundation.

The basic purposes of the Foundation are (1) to help *all* high school youth understand the fundamental principles of science, engineering, and technology, and (2) to help *able* high school youth to become interested in

and to prepare for careers in these fields and in science teaching.

The financial support given to the Foundation by industries and societies has increased very satisfactorily, from an initial budget of $3,000 in 1952 to actual contributions of about $47,000 during 1955. A much wider participation of industry will be sought for next year so that the Foundation can proceed with the expanded program recommended by the Advisory Committee.

The activities of the Foundation can perhaps best be described by a brief account of a meeting last fall of the Administrative Committee with the Advisory Committee, in which accomplishments for 1955 were reviewed and plans for 1956 were formulated.

1. *Science Achievement Awards for Students*

In this program, sponsored for the fourth year by the American Society for Metals, awards and honorable mentions were given to more than 450 students in 186 high schools in 41 states. The program will be continued into 1956 and, if possible, expanded.

2. *Summer Conferences for Teachers*

These conferences have been given financial support by the Crown-Zellerbach Foundation. The first, in 1954, dealt with the identification of laboratory skills which are a hazard to science students. The second, in 1955, dealt with the mathematical hurdles to success in high school science teaching. The teachers in these conferences are used as a research team, and the results of their studies are published and made available to other teachers. This program will be continued and, if possible, expanded in other parts of the country for 1956.

3. *Bibliography of Career Information and Guidance Material*

The third edition of this bibliography was published in 1955. This service, which the Advisory Committee considered of much value, will be continued and, if possible, expanded in 1956.

4. *Science-related Summer Jobs*

This program will be continued for its third year in 1956, with FSAF playing a catalytic role and not attempting to set up a central clearing house.

5. *Science Teachers Research Assistantships*

During the summer of 1955, about 45 science teachers were placed as research assistants on 18 campuses. Their experiences will be publicized in an Evaluation Report now being prepared. This service will also be continued in 1956.

6. *"If You Want to Do a Science Project"*

A booklet with this title was developed to help students get started on science projects. The Advisory Committee considered it valuable to both teachers and students.

7. *"Tomorrow's Scientists"*

A new eight-page monthly publication will be tested in the spring of 1956. It will contain stories of the work of today's scientists and what that work means for tomorrow, announcements of scholarships, student work reports, and similar items of interest.

8. *"Careers in Science Teaching"*

This booklet portrays science teaching, and is published as an effort to interest more students in preparing for this much needed profession. It has been widely circulated among students, and it is planned to distribute at least 10,000 copies during 1956.

(Copies of the publication "Facts About the FSAF" are available from the Foundation, National Science Teachers Association, 1201 Sixteenth Street, N.W., Washington 6, D. C.)

NUCLEAR RESEARCH PROJECTS IN MECHANICAL ENGINEERING

1. Effect of wetting on boiling heat transfer.
2. Effect of acoustic vibrations on convective heat transfer.
3. Heat transfer in thermal-entrance regions.
4. Nuclear energy in relation to the oil industry.
5. High flux heat transfer to boiling water.
6. Heat transfer up to high boiling rates from wire configuration to sub-cooled and saturated water.
7. Investigation of changes resulting from radiation damage to materials.

The above topics have been submitted by Herbert S. Isbin, Associate Professor of chemical engineering, the University of Minnesota, as a supplement to his article, "Survey of Nuclear Engineering Research," which appeared in the September, 1955, JOURNAL.

DR. ALBERT H. COOPER

Dr. Albert H. Cooper, a member of the ASEE since 1936 and Editor of the Chemical Engineering Division, has joined America Hard Rubber Company as an assistant to W. M. Bergin, Director of Research and Development. A well-known authority on organic and inorganic chemicals. Dr. Cooper will devote a major part of his time to chemical research and allied production programs. He will continue as Head of the Chemical Engineering Department at Pratt Institute, Brooklyn.

GUIDANCE MATERIALS FOR MATHEMATICS

A Selected Bibliography

This list is published at the request of the Secondary Schools Committee of ECAC. Thanks are due Dr. Eugene Nichols, formerly of the University of Illinois Committee on School Mathematics Experimental Project, for making available the publications concerned. (The order of presentation is alphabetical, not evaluative.)

1) *Careers for Mathematicians.* Monograph No. 5, Career Publications, 14 West 45th Street, New York 36. *Price* $1.00. (Leading national employers describe mathematical positions open to young graduates.)
2) *Catalogue of General Electric Publications for Schools.* (8 pp. All GE publications listed are free on request to Department 2-119, The General Electric Company, Schenectady 5, New York).
3) *GE's Answer to Three Why's.* (Why study math, science, engineering; 10 pp.) *GE's Answer to Four Why's.* (Study, work, English, read; 12 pp.) *GE Looks at Engineering Tomorrow.* (Career for the future; 4 pp.)
4) *Math at General Electric.* (Sample problems in various areas; 15 pp. of industry applications.)
5) *Why Study Math?* (What math is, why know it, occupations that use it; 8 pp.)
6) Guidance Pamphlet in Mathematics for High School Students. National Council of Teachers of Mathematics, 1201 Sixteenth Street, N.W., Washington 6, D. C. *Price* 25¢ per copy; 40 pp. (Occupational breakdowns of how much and what kinds of mathematics are needed in various professions, plus geographical list of colleges offering the doctorate in mathematics; selected references.)
7) "Mathematical Preparation for College," by P. D. Edwards, P. S. Jones, and B. E. Meserve. Reprint from *The Mathematics Teacher* (Vol. XLV, May, 1952); available from the National Council. *Price* 25¢ per copy. (Lists occupations requiring *high school* training in mathematics, with a little on college-level occupations; 12 pp. Considered "very good" by high school teachers.)
8) *Math Problems from Industry.* (Chrysler Corporation sample practical puzzlers, illustrated with blueprint drawings; 51 problems.) Free on request to Educational Services, Chrysler Corporation, Post Office Box 1919, Detroit 31, Michigan.
9) *Answers to Math Problems from Industry.* (Teacher's hints on methods and numerical solutions to problem volume.) Chrysler Corporation; free as above.
10) *Why Study Mathematics?* The Canadian Mathematical Congress, Engineering Building, McGill University, Montreal, Canada. 33 pp., *price* 50¢ per copy. (Excellent discussion of mathematical careers in broad terms: those requiring expert knowledge, special fields, and "substantial foundation" study. Also, the

mathematics needed in the education of a competent citizen; the contribution of mathematics to sound reasoning in other fields, and the rewards of mathematical training in intellectual and aesthetic satisfaction! Includes "suggestions for further reading." Considered "very good" by high school teachers.)

GORDON RESEARCH CONFERENCES

The 1956 Gordon Research Conference of the American Association for the Advancement of Science will be held from June 11 to August 31 at three New Hampshire schools: Colby Junior College, New London; New Hampton School, New Hampton; and Kimball Union Academy, Meriden. Established to stimulate research in universities, research foundations, and industrial laboratories, the conferences consist of scheduled lectures and discussion groups. Topics included in the approximately 36 week-long sessions of special interest to ASEE members are Instrumentation, Metals at High Temperatures, Chemistry and Physics of Metals, Statistics in Chemistry and Chemical Engineering, Adhesion, Stream Sanitation, Nuclear Chemistry, Chemistry and Physics of Isotopes, Solid-State Studies in Ceramics, Ion Exchange Factors, High-Pressure Research, Infrared Spectroscopy, and Characteristics of Strength, Fracture, and Surfaces for Glass. While registration has been filled for the series by some 3000 participating scientists, substantially the same programs are presented each year. Inquiries for information about the 1957 schedule may be directed to AAAS, 1515 Massachusetts Avenue, N.W., Washington, D. C.

DISCUSSION OF "RISK ANALYSIS"

An expansion and application of Risk Analysis techniques as presented by F. A. Gitzendanner (JOURNAL, October, 1955, p. 182) has been received and accepted by the author too late for publication in this issue. It is, however, available for use by any readers who may be interested, and will be published as early in the fall as possible.

NEW MEMBERS OF THE ASEE

The following two groups of new members conclude the lists for the year 1955–56. The first includes members as of May 7; the second, those to May 22, 1956.

BACIK, RICHARD JAMES, Staff Administrator in Education, American Society of Tool Engineers, Detroit, Michigan. W. Leighton Collins, K. J. Trigger.

BACKUS, KERBY DEWEL, Instructor in Engineering Drawing, The Rice Institute, Houston, Texas. A. P. McDonald, L. B. Ryon.

BALTER, LESLIE M., Director, Jersey City Technical Institute, Jersey City, New Jersey. D. C. Metz, K. J. Holderman.

BAREITHER, HARLAN DANIEL, Associate Professor in Mechanical Engineering, University of Illinois, Urbana, Illinois. N. A. Parker, S. Konzo.

BECK, BETTY ANNE, Research Engineer, Denver Research Institute, Denver, Colorado. J. A. McGlothlan, A. M. Krill.

BERGDOLT, VOLLMAR E., Assistant, Engineering Experiment Station, Purdue University, West Lafayette, Indiana. J. B. Jones, C. W. Rezek.

BIRKEMEIER, WILLIAM PHILIP, Instructor of Electrical Engineering, Purdue University, Lafayette, Indiana. J. S. Johnson, P. Weinberg.

BLEKKING, EARL HENRY, Interim Instructor in Industrial Engineering, University of Florida, Gainesville, Florida. E. P. Martinson, A. C. Kleinschmidt.

BRUCE, JOHN P., Instructor in Pattern Making, Wentworth Institute, Boston, Massachusetts. H. R. Beatty, F. H. Linton.

BRYAN, WILLIAM L., Associate Professor in Mechanical Engineering, Case Institute of Technology, Cleveland, Ohio. E. Laitala, W. E. Nudd.

CARLSON, DALE ARVID, Instructor in Civil Engineering, University of Washington, Seattle, Washington. R. H. Meese, R. H. Bogan.

CARROLL, J. RAYMOND, Associate Professor of Mechanical Engineering, University of Illinois, Urbana, Illinois. W. L. Hull, N. A. Parker.

COOPER, ROBERT MARION, Assistant Professor of Engineering Mechanics, University of Michigan. Ann Arbor, Michigan. T. A. Boyle, W. E. Thomas.

DINKER, JOHN D., Associate Professor of Civil Engineering, University of Pittsburgh, Pittsburgh, Pennsylvania. W. I. Short, A. Ackenheil.

DONNELLY, JAMES BERNELL, Instructor in Mechanical Engineering, Villanova University, Villanova, Pennsylvania. J. S. Morehouse, J. N. Walton.

DUCK, HOWARD BECTON, JR., Instructor in Engineering Drawing, Rice Institute, Houston, Texas. A. P. McDonald, L. B. Ryon.

DUNNING, ERNEST LEON, Associate Professor of Mechanical Engineering, Louisiana Polytechnic Institute, Ruston, Louisiana. J. J. Thigpen, J. C. Chumbley.

DUQUETTE, DOUGLAS DONALD, Lecturer in Engineering Mathematics, Assumption University, Windsor, Ontario. D. C. Hunt, J. Gerardi.

EISENSTADT, RAYMOND, Assistant Professor in Mechanical Engineering, Union College, Schenectady, New York. A. Hoadley, G. Ketchum.

ELNAN, ODIN, Assistant Professor of Aeronautical Engineering, University of Cincinnati, Cincinnati, Ohio. H. K. Justice, D. J. Schleef.

FLECKENSTEIN, EDWARD LOUIS, Head of Electrical Engineering Technology, Ohio Mechanics Institute, Cincinnati, Ohio. P. K. Johnston, K. R. Miller.

FONTAINE, WILLIAM E., Professor of Mechanical Engineering, Purdue University, Lafayette, Indiana. J. B. Jones, C. W. Rezek.

GUNNING, HENRY C., Dean of the Faculty of Applied Science, University of

British Columbia, Vancouver, British Columbia. W. O. Richmond, A. D. Moore.

HALSTEAD, WILLIAM ROBERT, Head of Electrical and Electronics Departments, Southern Technical Institute, Chamblee, Georgia. L. V. Johnson, M. R. McClure.

HAYS, FRANK D., Assistant Professor of Technical Institute, Purdue University, Lafayette, Indiana. J. C. Rapalski, C. F. Rhodes.

HEAD, GEORGE PECHAM, Instructor of Architectural Engineering, University of Detroit, Detroit, Michigan. L. R. Blakeslee, H. Gudebski.

HUBERT, CHARLES IRVING, Associate Professor in Electrical Engineering, U. S. Merchant Marine Academy, Northport, New York. E. W. Starr, P. Nudd.

KAUFMAN, JOSEPH JERRY, Design Instructor, Academy of Aeronautics, New York, New York. W. M. Hartung, A. N. Behr.

KEEGAN, FRANK J., Director, Keegan School of Television, Memphis, Tennessee. D. C. Metz, W. L. Collins.

KOPP, EDGAR WILLIAM, Assistant Professor in Industrial Engineering, University of Florida, Gainesville, Florida. E. P. Martinson, A. C. Kleinschmidt.

LAUGHLIN, HERMAN GLEYN, Assistant Professor in Mechanical Engineering, Purdue University, Lafayette, Indiana. A. R. Holowenko, C. W. Rezek.

MACFARLANE, CARL SHAW, Director of Admissions, Ohio Mechanics Institute, Cincinnati, Ohio. P. K. Johnston, K. R. Miller.

MACKEY, ALAN ANDREW, Assistant Professor in Mathematics, Northeastern University, Boston, Massachusetts. F. R. Henderson, W. C. White.

MCKINNEY, ROSS ERWIN, Assistant Professor of Sanitary Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts. W. L. Collins, J. C. Dietz.

NOEL, SIDNEY QUIN, President, Universal Television System, Inc., Kansas City, Missouri. J. I. Miller, T. J. Rung.

NOLAN, WILLIAM MARCUS, Technical Personnel Recruiter, American Viscose Corporation, Philadelphia, Pennsylvania. B. B. Bright, W. F. Houghton.

NOVAK, LOUIS, Instructor in Drafting, Wentworth Institute, Boston, Massachusetts. P. H. Ferzoco, R. A. Wilder.

OWENS, OWEN G., Associate Professor in Electrical Engineering, Union College, Schenectady, New York. H. W. Bibber, C. F. Goodheart.

PATTERSON, RALPH E., JR., Associate Professor in Engineering Extension, Iowa State College, Ames, Iowa. G. R. Henninger, L. O. Stewart.

POLAND, ROBERT LOUIS, Counselor, Ohio Mechanics Institute, Cincinnati, Ohio. P. K. Johnston, K. R. Miller.

PUGH, DAVID B., Industrial Supervisor, The Ohio Mechanics Institute, Cincinnati Ohio. P. K. Johnston, K. R. Miller.

RAMACHANDRAN, ARCOT, Assistant Professor of Mechanical Engineering, Indian Institute of Science, Bangalore, India. J. B. Jones, C. W. Rezek.

RAMMEL, WILLIAM GREGORY, Instructor in Building Construction, Purdue University, Fort Wayne, Indiana. V. Daugherty, M. D. Adams.

RENZ, ALLEN GEORGE, Instructor in Engineering Drawing, Washington University, St. Louis, Missouri. H. E. Grant, G. Nadler.

RESWICK, JAMES B., Assistant Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts. J. E. Arnold, W. M. Rohsenour.

ROGNESS, M. L., Assistant Professor in Engineering Drawing, Iowa State College, Ames, Iowa. C. Foster, C. A. Arnbal.

RUMPS, PAUL PETER, JR., Instructor in Chemical Engineering, University of Detroit, Detroit, Michigan. H. Gudebski, C. G. Duncombe.

SCHMID, MERLE D., Assistant Professor in Industrial Management, Pudue University, Lafayette, Indiana. V. W. Daugherty, W. L. Collins.

SLAVEN, G. C., Instructor in Engineering, West Virginia Institute of Technology, Montgomery, West Virginia. D. H. Pletta, H. W. Speiden.

SOLBERG, ARCHIE NORMAN, Dean of Research and Special Services, University of Toledo, Toledo, Ohio. E. D. Harrison, E. W. Weaver, Jr.

SORENSEN, SVEND ERIK, Instructor in Mechanical Engineering, Ohio University, Athens, Ohio. E. J. Taylor, P. H. Black.

SUTER, ANNA K., Assistant Professor of Mathematics, Purdue University, Lafayette, Indiana. A. W. Collins, W. L. Collins.

SWANSON, ROGER PAUL, Head of Aircraft Department, Wentworth Institute, Boston, Massachusetts. H. R. Beatty, F. H. Linton.

THOMPSON, WARREN H., Instructor in Industrial Electricity, Wentworth Institute, Boston, Massachusetts. H. R. Beatty, F. H. Linton.

THOREN, THEODORE ROOSEVELT, Staff Director in Engineering Research and Development, Thompson Products, Inc., Cleveland, Ohio. E. J. Massard, W. L. Collins.

VERRECCHIA, THOMAS ANTHONY, Instructor in Electronic Department, Wentworth Institute, Boston, Massachusetts. H. R. Beatty, F. H. Linton.

WESTFALL, CLAUDE ZEBEDEE, Instructor in Engineering Graphics, University of Maine, Orono, Maine. E. R. Weidhaas, M. McNeary.

WILSON, RICHARD C., Instructor in Mechanical Engineering, University of Michigan, Ann Arbor, Michigan. T. A. Boyle, W. E. Thomas.

WOJCIESZAK, LEO L., Senior Instructor, Academy of Aeronautics, New York, New York. W. M. Hartung, C. S. Jones.

59 new members

Final list as of May 22, 1956

ALLEN, WYETH, Professor of Industrial Engineering, University of Michigan, Ann Arbor, Michigan. F. L. Schwartz, G. G. Brown.

BAYER, CHARLES HENRY, Consultant to Engineering Services, General Electric Company, Schenectady, New York. M. M. Boring, H. G. Hutton.

BEER, CRAIG EUGENE, Instructor in Agricultural Engineering, Iowa State College, Ames, Iowa. K. K. Barnes, H. Beresford.

BELMAN, B. IRAN, Instructor of Graphics and Engineering, Fresno Junior College, Fresno, California. D. E. Whelan, Jr., H. H. Wheaton.

BERGSTROM, ROBERT EARL, Instructor in Product Engineering, General Motors Institute, Flint, Michigan. H. M. Dent, Earl D. Black.

BRUCE, JAMES D., Assistant Professor of Electrical Engineering, West Virginia Institute of Technology, Montgomery, West Virginia. R. M. Kerchner, E. L. Sitz.

BURCHINAL, JERRY CAMERON, Assistant Professor of Civil Engineering, West Virginia University, Morgantown, West Virginia. M. J. Smith, W. H. Baker.

BYRNE, SYDNER HUMMER, Assistant Dean of Engineering and Architecture, Virginia Polytechnic Institute, Blacksburg, Va. G. A. Barnes, Jr., J. W. Sjogren.

CHANDLER, ALFRED D., JR., Assistant Professor of History, Humanities, Massachusetts Institute of Technology, Cambridge, Mass. M. M. Boring, W. L. Collins.

CHOATE, DAVID C., Chairman of Engineering Graphics, Ohio Mechanics Institute, Cincinnati, Ohio. P. K. Johnston, K. R. Miller.

CLEMENTSON, GERHARDT CHRISTOPHER, Professor of Aerodynamics, U. S. Air Force Academy, Aurora, Colorado. A. Higdon, J. D. Hempstead.

DACCARDO, SAMUEL, Evening Instructor in Technical Drawing, Illinois Institute of Technology, Chicago, Ill. J. T. Dygdon, E. V. Mochel.

ECKBERG, HERBERT FREDERIC, Professor of Mechanical Engineering, Bucknell University, Lewisburg, Pennsylvania. H. D. Sims, W. Garman.

ECKEL, JAMES ROBERT, JR., Instructor in Electrical Engineering, University of Tennessee, Knoxville, Tennessee. W. O. Leffell, J. D. Tillman.

ELKINS, RICHARD LONSDALE, Instructor in Mechanical Engineering, University of Maryland, College Park, Maryland. J. E. Younger, R. W. Hurlbrink, Jr.

FISCHER, RICHARD JEFFERSON, General Personnel Supervisor, N. W. Bell Telephone Co., Des Moines, Iowa. L. O. Stewart, M. S. Coover.

GRIFFITH, EDWIN GEORGE, Instructor in Electrical Engineering, Allentown Extension Center, Pennsylvania State University, University Park, Pennsylvania. V. E. Neilly, H. J. Herbein.

HAMLIN, ROGER B., Instructor in Engineering and Cultural Studies, General Motors Institute, Flint, Michigan. H. O. Haskitt, Jr., M. H. Swift.

HARMS, WILLIAM OTTO, Assisttant Professor of Chemical Engineering, University of Tennessee, Knoxville, Tenn. E. E. Stansbury, H. F. Johnson.

HEARN, EMMETT E., Director of Employment, The Glenn L. Martin Company, Baltimore, Maryland. H. S. Stillwell, J. E. Dahlman.

HENSON, JAMES O., Lecturer in Civil Engineering, University of Tennessee, Knoxville, Tennessee. R. F. Bullock, A. T. Granger.

HERTENSTEIN, HAROLD NELSON, Supervisor, Engineering Training, McDonnell Aircraft Corporation, St. Louis, Missouri. G. E. Dreofke, F. H. Roever.

HOBSON, JAMES WALKER, Assistant to the President—Administrative, Lawrence Institute of Technology, Highland Park, Michigan. M. M. Ryan, E. Lawrence.

HOGAN, RANDALL JAMES, Instructor, Engineering Extension, The Pennsylvania State University, University Park, Pennsylvania. E. M. Elias, T. R. Horn.

HWANG, MING CHAO, Instructor in Mathematics, Academy of Aeronautics, New York, New York. A. Behr, C. H. Coder, Jr.

JAGGARD, ERNEST PLACK, Instructor in Engineering Extension, The Pennsylvania State University, University Park, Pennsylvania. K. L. Holderman, T. A. Wright.

JOHNSON, FRED M., Associate Engineer, Lawrence Adams Co., Modesto, California. D. E. Whelan, Jr., J. E. Sakaly.

LEE, MARY HELEN, Engineering Librarian, Purdue University, Lafayette, Indiana. A. K. Branham, G. A. Leonards.

LIND, TOIVO A., Project Engineer, Tractor Engineering Test & Development, Ford Motor, Tractor & Implement, Dearborn, Michigan. H. E. Hedinger, G. P. Brewington.

LINEBARGER, ROBERT MEAL, Part-time Instructor in Civil Engineering, Brigham Young University, Provo, Utah. D. K. Fuhriman, B. Brown.

MYSINGER, EDWARD DOUGLAS, Instructor in Civil Engineering, University of Tennessee, Knoxville, Tennessee. R. E. Bullock, A. T. Granger.

MCCLELLAND, FRANK MORGAN, Instructor in Electrical Engineering, University of Tennessee, Knoxville, Tennessee. H. M. Scull, W. O. Leffell.

PEASE, DONALD A., Specialist in Engineering Training, General Electric Company, Small Aircraft Engine Department, West Lynn, Massachusetts. J. C. Truman, J. R. Levitt.

PENZIEN, JOSEPH, Assistant Professor of Civil Engineering, University of California, Berkeley, California. E. P. Popov, B. Jameyson.

PERDUE, JOHN VICTOR, Industrial Coordinator, University of Detroit, Detroit, Michigan. S. J. Hirschfield, C. J. Freund.

PUNCOCHAR, ROBERT P., Instructor in Mechanical Engineering, South Dakota State College, Brookings, South Dakota. L. Amidon, K. E. Lindley.

RAU, ARTHUR H., Consultant to Engineering Services, General Electric Company, Schenectady, New York. M. M. Boring, H. G. Hutton.

REAL, RAYMOND V., Instructor in Engineering Mechanics, University of Nebraska, Lincoln, Nebraska. D. N. Pierce, D. I. Cook.

RUBIN, LLEWELLYN ADAM, Assistant Instructor in Electrical Engineering, Moore School of Electrical Engineering, University of Pennsylvania, Drexel Hill, Pennsylvania. Ernest Frank, H. Sohon.

SEARCRIST, GEORGE KENNETH, Instructor in English, the Pennsylvania State University (York Center), University Park, Pennsylvania. E. M. Elias, T. R. Horn.

SESONSKE, ALEXANDER, Associate Professor of Chemical Engineering, Purdue University, Lafayette, Indiana. S. C. Hite, T. J. Hughel.

SMITH, ALBERT P., Instructor in Engineering Extension, The Pennsylvania State University, University Park, Pennsylvania. H. J. Herbein, T. J. Rung.

SMITH, DONALD HUBBELL, Instructor in Engineering, The Pennsylvania State University Center, University Park, Pennsylvania. K. L. Holderman, T. J. Rung.

SNYDER, HARRY R., Coordinator of General and Industrial Education, Arabian American Oil Co., Dhahran, Saudi Arabia. E. E. Booher, K. Zeigler.

SPIES, HENRY RAYMOND, Assistant Editor, Engineering Experiment Station, University of Illinois, Urbana, Illinois. E. C. McClintock, R. J. Martin.

STEWART, WALTER WM., Staff Assistant in R & D Department, American Viscose Corporation, Philadelphia, Pennsylvania. W. F. Houghton, B. B. Bright.

TOMLINSON, MAURICE JOHN, Head of Department of Construction, Provincial Institute of Technology and Art, Calgary, Alberta, Canada. E. W. Wood, W. L. Collins.

WERNER, HAROLD D., Instructor in Engineering Extension, Pennsylvania State University, University Park, Pennsylvania. K. L. Holderman, T. J. Rung.

ZIMMERMAN, JOHN R., Instructor in Engineering Extension, Pennsylvania State University, University Park, Pennsylvania. H. Herbein, K. L. Holderman.

59 new members as of May 7
49 new members—final list
531 previously added

639 total new members 1955–56

MELVIN L. ENGER

Dean Emeritus Melvin L. Enger died May 13, 1956, in Escondido, California, where he has lived since retiring seven years ago from the position of Dean of Engineering at the University of Illinois, Urbana. Professor Enger, who served on the Illinois engineering faculty for 42 years, also became director of the Engineering Experiment Station in 1934, when he was appointed Dean. A member of the ASEE since 1907, Dean Enger was a member of the General Council from 1921 to 1924, and Vice President from 1938–39.

TEACHING POSITIONS AVAILABLE

ELECTRICAL, MECHANICAL, CHEMical Engineering, and also Mathematics and Physics staff openings. Industrial experience desirable. Opportunity for research. Franklin Technical Institute, 41 Berkeley Street, Boston 16, Massachusetts.

ASSISTANT PROFESSOR OR INSTRUCtor to teach fundamental heat power and related fields. Compensation dependent on qualifications. Long established college, high professional reputation. Graduate Study opportunities available. Location, New York City. Appointment to start September, 1956. Send resumé. JUN-1.

ASSOCIATE PROFESSOR, ASSISTANT Professor, or Instructor, (rank and salary determined by training and experience) to teach courses in the Petroleum Production Option. Teaching period nine months. Opening, September 1, 1956. Location, Southwest. JUN-2.

ASSOCIATE, ASSISTANT, PROFESSOR or Instructor, rank dependent upon training and experience, to teach basic mechanical engineering courses. Machine design experience preferred. M.S. degree or teaching experience desirable. Position available September 1, 1956. Write to Head, Department of Mechanical Engineering, South Dakota State College, State College Station, Brookings, S. D.

ELECTRICAL ENGINEERING INstructors and Professorial rank teachers needed for the 1956–57 academic year. Extensive graduate program and research activities. Write to Head, Electrical Engineering Department, The Pennsylvania State University, University Park, Pennsylvania.

RESEARCH ASSISTANTSHIP IN LUBRIcation. Graduate study and paid part-time work with experienced staff in hydrodynamic lubrication of bearings. Start September or February. Write to Professor George DuBois, Department of Machine Design, Cornell University, Ithaca, New York.

CIVIL ENGINEERING INSTRUCTOR and Assistant Professor needed. Assistant Professor to take charge of surveying, highway course sequence, and surveying camp. Eastern metropolitan college, start September 1, 1956. JUN-3.

ELECTRICAL ENGINEERING POSITION to teach undergraduate courses. M.S. required. Opportunity for graduate study, industrial consulting, or research. Rank and salary open. Start September 1956. University of Santa Clara, Santa Clara, California.

ASSISTANT PROFESSOR AND INSTRUCtor at growing midwest engineering college in Department of Mechanical Engineering, effective fall semester 1956–57. Assistant Professor must have special experience or training in machine design. Teaching assignment for instructor would include: Heat-Power, Manufacturing Processes, and Laboratory. Salary in both grades dependent upon qualifications. JUN-4

EJC Report on Professional Standards and Employment Conditions

Editorial Note: If engineering is to be accepted fully as a profession in the strict sense, engineers, their employers, and colleges of engineering all have responsibilities. What are they? The Committee on Employment Conditions of Engineers Joint Council studied the problem, prepared a report, had it reviewed by a special Task Committee, reviewed again by the EJC Executive Committee, and finally approved by the EJC Board of Directors at its meeting on March 16, 1956.

As an authoritative statement of the problem, the report is printed here in its entirety for the benefit of ASEE members; other constituent societies are giving it similar circulation. In addition, EJC is printing a limited number of separate copies. Some are being sent to each dean of engineering, and others are being made available without charge to those interested. Requests should be sent to E. Paul Lange, Secretary, Engineers Joint Council, 29 West 39th Street, New York 18.

FOREWORD

Unlike the members of most learned professions, the engineer usually is an employee rather than a private practitioner. Surveys indicate that about eighty per cent of professional engineers are in the employee classification, and this situation sometimes creates special problems which are not inherent in the other professions. One such problem is how specifically to create and maintain an employment atmosphere consistent with high professional standards.

Certain conditions of employment have had a profound influence on engineers and, among other factors, have caused a number of professional employee groups to turn to collective bargaining. There is a need, therefore, for the engineering profession to state clearly the employment conditions that engineers expect as professional men. Employers should align their policies with respect to the engagement of professional engineering personnel to meet these expectations. Mutual understanding between employers of engineers and the engineering profession is essential to the establishment of an environment which will encourage the individual engineer to achieve full professional stature.

A special committee of Engineers Joint Council was charged with a study of this employment problem and the preparation for Engineers Joint Council of "a means of education of and vertical communication to the membership of the constituent societies (including students) concerning conditions surrounding unionization of professional personnel."

Another assignment of the special committee was the preparation of information for employers of engineers concerning employment practices, educational opportunities, and general measures for pro-

fessional development that influence the attitudes of engineers toward a true professional outlook.

This study treats but one of many problems confronting the profession. Engineers Joint Council will continue its study of the problems related to the employed engineer.

ENGINEERS JOINT COUNCIL REPORT ON PROFESSIONAL STANDARDS AND EMPLOYMENT CONDITIONS

The Board of Directors of Engineers Joint Council has adopted the following report, which comprises an analysis of problems of current employment conditions as they relate to the individual engineer. The major topics studied and covered in this report are as follows:

1. The Present Situation
2. The Causes of This Condition
3. Summary of Historical Background
4. Statement of the Problem and Suggested Solutions
5. Engineering—a Profession
6. Employee's Responsibilities in the Engineering Profession
7. Management's Responsibilities in the Engineering Profession
8. Engineering Societies' Responsibilities in the Engineering Profession
9. Engineering Education's Responsibilities in the Engineering Profession
10. Conclusions and Recommendations

1. The Present Situation

The expansion of engineering from its beginning in military and civil engineering a century ago to a multiplicity of disciplines today has created a host of problems. Of major concern to the engineer is his relationship as a professional man with his employer. This relationship is influenced largely by employment conditions, including salaries, training programs, security policies, levels of responsibility, job classifications, and identification with management.

Because the needs, responsibilities, and contributions of professional employees have not been recognized adequately in some instances, there has been a movement toward the unionization of engineering personnel. This has had an adverse affect on the professional concepts of many engineers, for a professional man must rely primarily on his own personal competence and integrity for recognition. In addition, confidential relationships which should exist between employers and professional engineers have been jeopardized.

The fact that there has been a trend toward collective bargaining by engineers, in spite of widespread reluctance to participate in such action, indicates the existence of unsatisfactory conditions. The engineering profession and management have a great stake in the solution of the problem and the latter must accept its share of

the responsibility for alleviating unfavorable employment conditions.

2. The Causes of this Condition

Reasons which have fostered collective bargaining among engineers have been studied and may be grouped as follows:

A. *Professional Treatment*

a. A feeling among engineers that they were not identified with management, whether they were employees in industry, in private engineering firms, or in the public service.
b. Inadequate channels of communication between top management and nonsupervisory engineers.
c. Inadequate recognition of the engineer as a professional employee.
d. Assignment of engineers to subprofessional work.
e. Undue retention of engineers in specialized and narrowly compartmentalized assignments.
f. Lack of appropriate means for resolving individual problems.

B. *Personal Treatment*

a. Inadequate recognition and treatment of the engineer as an individual.
b. Lack of broad position classifications and appropriate titles by which the engineer could measure his progress.
c. Inadequate or nonexistent plans for training and job rotation.
d. Inadequate understanding of promotional policies and belief that progress and promotions were not commensurate with ability and performance.
e. Feeling of insecurity of employment.
f. Management's human relations knowledge and skills have not kept pace with the expanded utilization of engineers.

C. *Financial Treatment*

a. Engineering salaries not commensurate with fundamental contribution.
b. Too small a differential between the pay of engineers and members of the skilled trades.
c. Salaries of experienced engineers not sufficiently increased, in comparison with present starting salaries.
d. Wide variation in salaries paid to engineers doing comparable work in different organizations.
e. Dissatisfaction with merit review systems and inadequate understanding of salary administration.

Faced with these conditions, some engineers have resorted to unionization in the belief that corrective action could be effected only by pressures on management through collective bargaining. Even though they may have realized that professionalism requires freedom of action, these engineers appear to have been willing to submerge this principle in their attempt to get more pay and better working conditions through union activity.

3. Summary of Historical Background

The accelerated development of mass-production techniques in this century stimulated a rapid rise in labor union activities. Labor and management faced common problems of increasing complexity. In 1935 the United States Congress enacted the National Labor Relations Act, better

known as the Wagner Act, which guaranteed to employees the right to organize and to bargain collectively, and protected labor unions against specified unfair labor practices on the part of management. At that time there was little realization on the part of the professions of the potential impact of the Wagner Act on professional employees. However, the established labor unions soon took advantage of the situation, and it was not long until many professional employees found themselves included, against their individual desires, in heterogeneous bargaining groups.

Legally, it was possible to form bargaining groups composed solely of professional employees. Practically, it was difficult to do so. Wherever a heterogeneous bargaining unit existed, it was next to impossible for professional employees to segregate themselves since the Wagner Act made no distinction between them and nonprofessional workers.

Some engineering societies, particularly the American Society of Civil Engineers, undertook to chart a course of action designed to assist professional employees against inclusion in heterogeneous groups. At first, the effort met with but minor success. Later, Engineers Joint Council determined to present its views to Congress, with the hope that the Wagner Act might be amended to provide recognition of the status of professional employees and to enable them to act effectively on their own behalf. Pertinent clauses are included in the Labor-Management Act enacted by the Congress in 1947—better known as the Taft-Hartley Act.

Of interest to the engineering profession, this law specifically provides under Section 9 (b):

"The Board shall decide in each case whether, in order to assure to employees the fullest freedom in exercising the rights guaranteed by this ACT, the unit appropriate for the purposes of collective bargaining shall be the employer unit, craft unit, plant unit, or subdivision thereof; PROVIDED that the Board shall not (1) decide that any unit is appropriate for such purposes if such unit includes both professional employees and employees who are not professional employees unless a majority of such professional employees vote for inclusion in such unit. . . ."

The term *professional employee* as included in the Act reads:

"(a) any employee engaged in work (i) predominantly intellectual and varied in character as opposed to routine mental, manual, mechanical, or physical work; (ii) involving the consistent exercise of discretion and judgment in its performance; (iii) of such a character that the output produced or the result accomplished cannot be standardized in relation to a given period of time; (iv) requiring knowledge of an advanced type in a field of science or learning customarily acquired by a prolonged course of specialized intellectual instruction and study in an institution of higher learning or a hospital, as distinguished from a general academic education or from an apprenticeship or from training in the performance of routine mental, manual, or physical processes; or, (b) any employee who has (i) completed the courses of specialized intellectual instruction and study described in clause (iv) of paragraph (a), and (ii) is performing related work under the supervision of a professional person to qualify himself to become a professional employee as defined in paragraph (a)."

Under the Taft-Hartley Act, a group of professional employees in any place of employment may decide by majority vote of their own numbers whether they want to form a unit

of their own for collective bargaining purposes, to join with some other bargaining group, or to refrain from collective bargaining entirely.

It was hoped that the amended act would provide a satisfactory solution to the inclusion of engineers in heterogeneous unions. Professional employees could disassociate themselves from heterogeneous groups. It was not expected that employees of professional status ever would desire anything like a nation-wide bargaining union. It was hoped that labor unions would respect the statutory rights of professional employees. Those hopes today lack much of full realization.

A number of bargaining groups of professional employees have come into existence. Some appear to have functioned constructively; the same hardly can be said of others. Already there is a nation-wide union, self-designated as an engineering union, which aspires to power. Although some professional employees have been able to disassociate themselves from heterogeneous groups, craft unions, particularly in the construction industry, are forcing more and more engineers into their ranks by bringing economic pressure upon employees, thus avoiding the election machinery of the Taft-Hartley Act. Clearly, many members of the engineering profession and employers of engineers are not doing enough to ensure enforcement of the letter and the spirit of the law.

The recent merging of the American Federation of Labor (AFL) and the Congress of Industrial Organizations (CIO) brings into being a large and powerful labor organization among whose objectives are increased efforts toward unionization of office employees and technical personnel. That effort will have direct impact on professional engineers.

To obtain reliable statistics regarding the current status and thinking of a cross-section of the engineering profession, four constituent members of EJC, namely ASCE, ASME, AIEE, and SNAME, polled 117,917 of their members on specific questions concerning collective bargaining. Of those polled 66,938 or 57% responded. Returns showed that 48,082, or 72%, of the 66,938 respondents *opposed* collective bargaining for professional engineers; and that 44,168, or 66%, felt that collective bargaining is *incompatible* with professional status.

Further, the 66,938 responses showed that less than 4% were actually members of established collective bargaining groups; 27% reported as not being opposed to collective bargaining; 20% reported that they believed collective bargaining would be advantageous to them; and finally, less than 1% of the membership of three member societies (the fourth did not ask the question), would prefer to be represented by a craft labor union.

These results present a challenge to the engineering profession and to engineering management. The thinking of the remaining 43% of the 117,917 members polled, who did not respond to the questionnaire, is still unknown, but, assuming that the sample was representative, there would then be 30,300 members who are not opposed to collective bargaining for professional engineers.

These results emphasize the situation confronting the profession in spite of the protective clauses in the Taft-Hartley Act.

4. Statement of the Problem and Suggested Solutions

A summary of the above might lead to two basic reasons for the present situation:

1. Engineers have not always realized and understood the professional characteristics of their roles.
2. Management has not always realized and accepted its obligations to engineers.

If these are the causes, the problem then may be stated as how to get the engineer to appreciate the professional characteristics of his position and how to get management to realize and accept its obligations to its engineers.

Immediately certain solutions present themselves, and these may be listed under five main headings:

1. Point out to the engineer and reemphasize to him that engineering is a profession and that he therefore has certain definite responsibilities.
2. Point out to management, through all feasible ways, that it has responsibilities to the engineering profession.
3. Point out to professional societies the part which they should play in the advancement of their profession.
4. Point out to engineering educators their responsibilities for developing professional concepts in their students.
5. Point out to society the contribution of the engineer to its general welfare.

The purpose of the rest of this report will be to bring to the attention of all concerned their respective responsibilities. It is hoped that sufficient distribution and publicity will be given to it to stimulate a realization on the part of the public that engineering is a profession with high ideals and one that has made preeminent contributions to our modern civilization and high standard of living.

5. Engineering—a Profession

Engineering is the art and science by which the properties of matter and energy are made useful to man in structures, machines, and products. Accomplishment of these ends requires not only scientific training, but also creative imagination, judgment, and an appreciation of the economics involved. The work of the engineer is predominantly intellectual and varied. The dictionary defines engineering as a mental activity rather than a manual skill. The engineer must exercise discretion and judgment, he must wish to serve, and his relationship with management must be one of confidence; in fact he is part of management. The engineer is charged with the protection of the public health and the public safety. The builder of a bridge, an airplane, a water supply system, a dynamo, a kitchen range, an automobile, or a chemical plant must be concerned with its safe operation. Responsibility rests upon his shoulders; if he does not accept that responsibility, he is not professional.

Professions require knowledge and skills on a high plane, and all require that the practitioner work in a relation of confidence. In the ministry, medicine, and law, this relationship is usually on an intimate personal basis, but in engineering it usually is more general and, indeed, involves obligation to the public at large as well as to the employer or client. The engineer's code of ethics requires that "he will have due regard for the safety of life and health of the public and employees who may be affected by the work for which he is responsible" and

that "he will act in professional matters for each client or employer as a faithful agent or trustee."

Since clients and employers usually do not have the technical knowledge necessary to judge technical work, the engineer is bound to place their protection above his personal convenience or his immediate personal gain. A fundamental principle of professional responsibility is trusteeship. This is also a fundamental principle of management. To the employed engineer this means that the professional attitude involves a "management-oriented" point of view.

Engineering operations today are varied and extensive. Men at all levels of training and competence are required to carry out vast engineering enterprises. The work of the draftsman, the layout man, the toolmaker, the plant operator is indispensable, but does not require the imagination, the educational background, or the judgment of the engineer, who conceives and executes the broader aspects of the projects.

The work of a truly professional engineer is so far from a routine, established pattern that only he can provide the initiative, the discretion, and judgment to achieve the successful accomplishment of his particular tasks. Because he alone knows with what comprehension, ability, and likelihood of success he approaches his assignment, the professional must accept individual responsibility or else advise his client or employer that other help is needed.

Professional attitude involves the following five basic concepts:

(1) A social consciousness, a desire to contribute *to* rather than simply to benefit *from* civilization; a resolve to place the public welfare above other considerations.

(2) The acquisition of special skills on a high intellectual plane, generally evaluated by means of self-imposed standards of excellence.

(3) A sense of trusteeship—personal responsibility to protect the client's or employer's interest.

(4) Individual initiative and acceptance of individual responsibility, both of the highest order.

(5) A right to expect and to receive adequate financial recognition.

Prestige, however, is something that must be won. It cannot be bought or automatically accorded through affiliation with an organization. It is something that one can *command* but never *demand*. In the final analysis, an engineer achieves professional standing only to the extent that he accepts his responsibility to himself, to his client or employer, and to society.

Attainment of a degree in engineering from an institution of recognized standing implies that the graduate has mastered a certain curriculum and that he has the ability to understand, to assimilate, and to apply the knowledge that qualifies him to become a member of the engineering profession.

Although social consciousness is not necessarily a corollary to superior mental competence, most people who are endowed with such competence do have a sense of responsibility to the social order of which they are a part. They have learned to look on life as an opportunity to contribute to the civilization that fostered them and thus to better the lot of those who follow. To the engineer who feels that life provides opportunity for constructive contribution to society, collective bargaining with its attendant poten-

tiality for creating conflicting obligations is not acceptable.

6. Employee's Responsibilities in the Engineering Profession

"As an engineer, I will participate in none but honest enterprise. To him that has engaged my services, as employer or client, I will give the utmost of performance and fidelity." (Faith of the Engineer.)

The engineering employee is bound by the same ethical and moral principles that apply to a member of any other learned profession. The responsibilities of an engineering employee are many. He is obliged to perform the professional assignments entrusted to him to the best of his knowledge and ability. He should give needed professional counsel in his special field and render loyal service. He should respect the economic problems of his employer. He should be thorough, expeditious, original, and accurate in the execution of his duties and assignments. He should have a rational attitude toward his work and fulfill each task with a minimum of supervision. At all times he should strive to improve the quality and increase the quantity of his output.

Education is important to the engineer and he should foster its continuance for those who are subordinate to him. He should strive to recognize and to utilize the diverse capacities of all fellow employees. He should strive for good planning and clear, concise reports. He should be friendly and maintain good appearance. He should develop the ability to be a good listener as well as the ability to express his thoughts effectively.

It is axiomatic that just as management has responsibility to employees, so do employees have responsibilities to management. The engineer employee should realize that he is not just another hired hand. He should know that to achieve full professional stature he must develop himself to rise above the technician or engineering assistant. He must have genuine desire to expand his capacity, to extend his knowledge, and to improve his proficiency.

Any employee who is unwilling to assume responsibilities beyond those accompanying his present job has little right to be critical about lack of advancement. If he feels that he is not getting earned recognition, it well may be that critical self-appraisal is in order. One cannot just wish himself up the ladder or depend on someone else to push or pull him along the way to success. The fact that a man has acquired a bachelor's degree in engineering does not, of itself, entitle him to any lasting professional recognition. It remains for each individual to prove by his own ability, integrity and conscientious application to duty that he deserves recognition.

7. Management's Responsibilities in the Engineering Profession

Surveys show that more than forty per cent of management were trained as engineers. It seems illogical, therefore, that often there is inadequate communication between management and engineers, with consequent lack of understanding on the part of management of the reasons for dissatisfaction among professional employees.

Management must recognize the inherent professional character of engineering work. It should be a policy of management to use its professional employees to the maximum of their capabilities. Except during the training period, the engineer should not be assigned to tasks which do not require

his technical training and he should be accorded individual and professional status commensurate with the quality of his contribution.

There must be opportunity for a continuation of education. It is important that professional employees be given opportunities to participate in activities of scientific and technical societies. It is important that they receive credit for their contributions to the advancement of technical knowledge or the profession as a whole.

There must be adequate communication between management and the professional employee. There should be organized orientation and training programs for new employees. Engineers need to understand the basic policies of their employer. They need to know their responsibilities and their opportunities for advancement. Adequate management-employee communications require a day-to-day relationship supplemented by periodic performance reviews, and other appropriate techniques.

Salaries must be established which will recognize the contribution of the professional employees as related to that of other groups. Salary differentials between various levels of technical experience have been substantially narrowed during recent years. Engineers who, after a period of satisfactory employment, find their salaries are only slightly higher than those of the recent graduate and possibly lower than those of a skilled craftsman are not working in a favorable atmosphere.

Management must minimize the fear of job insecurity by adopting feasible means for stabilizing the employment of professional personnel and developing suitable termination policies. Since many engineers become managers, there is a need to insure that they are employed and developed in an atmosphere which will fit them for their future responsibilities. Executive talents must be developed by experience and training in those phases which lead to managerial responsibilities.

8. Engineering Societies' Responsibilities in the Engineering Profession

The engineering societies must take the lead in the advancement of the profession. Among the basic responsibilities of the engineering societies are the establishment of standards of ethical conduct, rigid requirements for admission to membership, accreditation of educational institutions which grant engineering degrees, and awards and prizes in recognition of worthy contributions to the advancement of the profession.

The national engineering societies have an additional responsibility to foster a healthy professional climate for employed engineers. Their governing boards and their individual members should unite in exerting their best efforts towards solving the problem. These responsibilities are so challenging and so vital to the current problem that they must be considered as obligations.

Current efforts of national committees to encourage professional development of engineering society members and to promote recognition by the public of the professional character of the engineers' work should be expanded. An objective evaluation of the problem should be continued, followed by specific recommendations for the good of the profession. Engineering societies should adopt official statements for membership information with respect to collective bargaining

to the extent permitted by their chapters and constitutions. They should acquaint their memberships with those provisions of the Taft-Hartley Act which have a special significance to professional engineers. Constructive programs for encouraging professional consciousness on the part of engineers both before and after graduation should be sponsored. Therefore, the engineering societies and Engineers Joint Council should inform management as to the standards that will contribute to full professional achievement.

The engineering societies should provide guidance and assistance to educational institutions confronted with any problem which is detrimental to the achievement of full professional training of students.

9. Engineering Educator's Responsibilities in the Engineering Profession

Engineering colleges have a primary responsibility for developing professional concepts in engineering students. Professional concepts should be developed through their application to the solution of engineering problems in the technical courses, by lectures, association with students, and by good example.

Opportunities for engineering educators to become better acquainted with the total environment in which engineers work should be expanded through temporary employment in nonacademic fields and the utilization of employers with "professional vision" in the classrooms and student seminars. Such activities enable students to appraise their status more realistically upon graduation.

10. Conclusions and Recommendations

There are obligations and responsibilities resting on both employer and employee. Each, of course, has responsibility to advance his own welfare. Beyond that, and yet a part of it, each has responsibility to the other and to society. Grave responsibilities for inculcating and developing professional consciousness in young members of the profession rest upon the educational institutions and professional societies. Various phases of such responsibilities have been stressed in the several sections of this report.

Without a sound technical foundation no man can become a competent engineer. But more than technical competence is demanded of one who expects to be recognized as a professional person. One must understand and observe appropriate ethical standards and it is important to cultivate proper understanding of such standards.

The ECPD program "The First Five Years of Professional Development" is an excellent step in the right direction. Here is opportunity for the engineering societies, the colleges, industrial management, and civic institutions to work together to aid young graduates in continuing their education and in adjusting themselves to conditions to be met in the practice of their profession.

The present report has been prepared with full realization that the subject refers chiefly to one phase of professional life. An attempt has been made to identify factors that have significant bearing on the specific problem under consideration. Concerted efforts by all concerned with advancement of the profession are required if satisfactory solutions are to be found. It is believed that if the recommendations submitted are followed by those to whom they are directed, substantial improvement in the

standing of the profession will result. There is no simple solution, but EJC recommends that:

1. Management utilize the services of engineers more effectively and thereby afford them opportunity for advancement and economic improvement.

2. Management recognize its responsibility to make engineers feel that they are a part of management.

3. Management survey areas of communication, recognition, and salaries and, where found wanting, correct to conform with standards of professional practice.

4. The engineer take inventory of his services and his actions to make sure that he has a professional attitude toward his work.

5. Engineering societies establish and employ appropriate means to maintain high standards of ethical conduct for professional achievement.

6. Engineering societies encourage the professional development of their members and promote proper recognition of the profession.

7. Engineering educators emphasize the characteristics of the profession.

SUBJECT INDEX

AIP Report on Role of Physics ..M, 512
Annual Meeting, 63rd, J. I. Mattill S, 14
Another Look at General Studies, Weller Embler .....M, 551
Art of Writing, J. H. Bolton .....O, 171
ASEE Directory Changes .....My, 797
ASEE Proceedings Volume .....Ja, 440
ASEE Summer Schools .....Ja, 502
ASEE Summer Schools .....A, 616
ASEE 1956 Yearbook and Directory .....F, 1–320
Award to Garrelts .....Ja, 476

Birth of a Research Project, H. A. M. Flanakin .....D, 358
Blurred Borders of Physics and Engineering, J. H. Van Vleck ..D, 366
Busman's Holiday, Harold A. Foecke M, 573

Can 500,000 Engineers be Professional? Eric A. Walker .....Ja, 421
Candid Comments, J. E. Dean ....S, 99
N, 286
R. H. Upson .....D, 401
M. Levine .....D, 402
"Case Studies" in Materials Laboratory, P. F. Brandenburg ....M, 563
Chicago Industry-Education Conference on Evaluation Report .My, 818
Civil Engineering Division—A. G. C. .....Je, 837
College Notes ....S, 75, 80, 93; O, 126, 131, 139, 159, 162, 170, N, 221, 250; D, 348, 352, 357; Ja, 477
Cooper, Dr. Albert H. .....Je, 857
Colorado A&M Center, New ..My, 794
Communication Problems in the Engineering Science Curriculum, W. E. Wilson .....D, 374
Construction Education Summer School .....M, 578
Cooper Made Chairman .....Ja, 474
Co-op. Educ. 50th Anniversary ..A, 617
Co-op Education Resolution ....A, 617
Cooperative Engineering Calendars, D. C. Hunt .....O, 168
Coordination of Architecture, Engineering, and Construction by the Project Method, J. F. Poulton .....D, 383
Corps of Engineers Student Program, Edward J. Rising ... .My, 771
Corrosion Instruction in Engineering Colleges, F. E. Allen ....N, 267
Cracking the Creative Nut, D. S. Pearson .....O, 121
Cronvich, James A., Dean .....My, 801

Designing the Educational Program, G. A. Hawkins .....N, 241
Discussion of "Risk Analysis" ...Je, 860
Do You Know ....S, 6; O, 107; N, 211; D, 309, Ja, 414; M, 528; A, 608; My, 752; Je, 824
Drawing and Graphic Science Summer School .....M, 570

Economics in Chemical Engineering, R. S. Aries and R. M. Cziner ..Ja, 446
Editorial—A Year of Decision ...S, 4
Editorial Policy .....Ja, 469
Educational Requirements for Technical Editors, Kalsem, P. J. ..Je, 832
Education by Research Training, J. T. Rettaliata .....D, 327
Education for Research in Industry, C. G. Kirkbride .....N, 216
Electron Microscope Course ....M, 550
ECPD Accreditation—Additional Criteria .....My, 816
ECPD Accreditation—Introduction, Harold L. Hazen .....My, 814
ECPD—Proposal for Survey of Profession, Thorndike Saville ....Ja, 500
ECPD—Resolution; Origins of Proposal, W. L. McCabe .....Ja, 501
ECPD—Toronto Address: Need for Appraisal, S. C. Hollister ....Ja, 503
EJC Proceedings .....Je, 835
EJC Report, Professional Standards .....Je, 866
Engineering Directory .....My, 789
Engineering Economy Committee Functions, Arthur Lesser, Jr. ..Ja, 498
Engineering Education in Brazil, E. W. Kimbark .....D, 353
Engineering Enrollments and Degrees, 1955, W. A. Jaracz, H. H. Armsby .....F, 509
Engineering Mechanics Survey, G. Wallace Smith .....M, 536
Engineering Research at Iowa State College .....My, 755
ECRC Research Review .....Ja, 457

ENGLISH PROGRAM AS ENGINEERING TEACHERS VIEW IT, Frank Kerekes Ja, 427
ENROLLMENT AND INCOMES IN CIVIL ENGINEERING CAN BE INCREASED, H. Rubey ....N, 236
EVALUATION OF ENGINEERING EDUCATION, J. K. Wolfe ....D, 342
EXECUTIVE BOARD MINUTES ..N, 290; Ja, 484; My, 807
EXTRA-CURRICULAR ACTIVITIES, Joseph F. Zimmerman ....My, 787

FIELD RESEARCH IN CIVIL ENGINEERING, Ardis White ....My, 768
FIGHT FOR ETHICS IN ENGINEERING, J. R. Snell ....N, 230
FOR WHAT TYPES OF CAREERS SHOULD WE TRAIN MATHEMATICIANS, R. S. Burington ....O, 115
FUTURE SCIENTISTS OF AMERICA FOUNDATION, Armsby, H. H. ....Je, 855

GENERAL EDUCATION IN ENGINEERING COMMITTEE REPORT FOR THE HUMANISTIC-SOCIAL RESEARCH PROJECT ....A, 619
GENERAL STUDIES FOR ENGINEERS, J. H. Davis ....O, 109
GENERAL COUNCIL MINUTES ..N, 294; Ja, 485
GEORGE WESTINGHOUSE AWARD, R. R. White ....S, 97
GORDON RESEARCH CONFERENCES .Je, 859
GRAPHIC SCIENCE: DESCRIPTIVE GEOMETRY HELPS SURVEYING INSTRUCTOR, R. P. Vreeland ....S, 100
GRAPHIC SCIENCE—IS ENGINEERING GRAPHICS A SCIENCE?, M. McNeary ....N, 303
GRAPHIC SCIENCE: CHAIRMAN'S MESSAGE, Wm. E. Street ....Ja, 475
GRAPHIC SCIENCE: MIDWINTER MEETING AND SUMMER SCHOOL ....M, 569
GRAPHIC SCIENCE: COURSE FOR SCIENCE MAJORS, Eugene Paré ....My, 798
GUIDANCE BIBLIOGRAPHY FOR MATHEMATICS ....Je, 858

HIGH SCHOOL SCIENCE FAIRS, Watson Davis ....O, 179
HOCKEMA, FRANK C. ....My, 806
HUMANISTIC-SOCIAL SUMMER SCHOOL M, 591
HUMAN RELATIONS IN ENGINEERING, B. von H. Gilmer and H. W. Karn ....M, 544

INDUSTRIAL FELLOWSHIP ANNOUNCEMENT, R. A. Morgen ....Ja, 496
INDUSTRIAL RESEARCH AND A PROFILE OF THE RESEARCH WORKER, E. W. Engstrom ....D, 311
INFLUENCE OF ASEE MISSION REPORT ON JAPANESE ENGINEERING EDUCATION, Kinji Shimizu ....N, 260
IN THE NEWS ..S, 24; O, 167; N, 289; D, 326, 365; Ja, 478; A, 617; My, 795
IOWA STATE COLLEGE—HOST FOR ASEE ANNUAL MEETING ....Ja, 417
IOWA STATE COLLEGE—A CAMPUS INTRODUCTION ....M, 531
IOWA STATE COLLEGE, ENGINEERING RESEARCH ....My, 755

"JETS" FOR HIGH SCHOOLS ....M, 559

KEREKES PRESIDENT ACI ....Ja, 426

LAMME AWARD, Vannevar Bush ....S, 94
LIBERAL SCIENTIFIC EDUCATION, James R. Killian, Jr. ....My, 793
LOCATION OF AMES, IOWA ....M, 530

MACELWANE, JAMES B. ....My, 806
MIT ADVANCED STUDY SCHOOL ...My, 775
MIT'S PRACTICE SCHOOL, Robert C. Reid ....Ja, 441
MATHEMATICAL BIBLIOGRAPHY ....Je, 858
MATHEMATICS CONFERENCE ....Ja, 452
MATHEMATICS IN ENGINEERING ....M, 585
MATHEMATICS TEACHER IN ENGINEERING, F. Virginia Rohde ....M, 555
MCGRAW AWARD JAMES H. ....N, 278
MECHANICAL ENGINEERS AND NUCLEAR POWER REACTOR DESIGN, Fritz, R. J. ....Je, 827
MECHANICS TEACHERS—THEIR CROSS AND THEIR CROWN, D. H. Pletta Ja, 453
MEMBERSHIP APPLICATION ....Ja, ix; M, x; My, x
MICHIGAN PROGRAMS ....Ja, 471
MICROWAVE ENGINEERING: HOW A NEW COURSE IS ADOPTED, Charles Süsskind ....Je, 838
MOTION AND TIME STUDY ....M, 568

NATIONAL ENGINEERS' WEEK ....D, 404
NSF GRANTS ....My, 792
NEED FOR MORE "KNOW-WHY," Jess H. Davis ....My, 790
NEEDS OF ELECTRIC POWER INDUSTRY FOR NUCLEAR ENGINEERS, R. W. Hartwell and H. A. Wagner ...O, 152
NEW JOURNAL EDITOR ....N, 214

NEW MEMBERS ....S, 104; O, 206; N, 306; D, 407; Ja, 481; M, 580; A, 611; My, 804; Je, 860
NEW LOWELL COURSE .....Ja, 460
NOMINATION BLANK .....Ja, x
NOTE TO AUTHORS .....My, 770
NUCLEAR ENGINEERING AND SCIENCE CONGRESS .....N, 268
NUCLEAR ENGINEERING RESEARCH, SURVEY, H. S. Isbin .....S, 76
NUCLEAR RESEARCH PROJECTS IN MECHANICAL ENGINEERING .....Je, 857

OAK RIDGE INSTITUTE .....M, 606
OFFICERS, DIVISION, COMMITTEE, AND SECTION .....O, 204
ON TEACHING DESIGN, Chesley J. Posey .....M, 547
ON TEACHING PHYSICAL MECHANICS, Seeger, R. J. .....Je, 842
OPERATION COOPERATION, W. L. Howland .....Ja, 467
OUR OUTPUT PROBLEM, E. J. Rising .D, 379

PHYSICS FOR ENGINEERS, J. A. Sauer and D. E. Hardenbergh .....D, 349
PHYSICS IS NOT ENGINEERING, R. J. Seeger .....O, 127
PLACE OF SOLID STATE PHYSICS IN ENGINEERING, H. V. Fairbanks ..N, 251
PREDICTION OF ENGINEERING POTENTIALITY IN HIGH SCHOOL STUDENTS, A. P. Johnson .....O, 135
PRESIDENT, M. M. BORING—BIOGRAPHY S, 1
PRESIDENTIAL ADDRESS, N. W. Dougherty .....S, 8
PROBLEMS IN NUCLEAR METALLURGY, Stuart McLain and Frank G. Foote .....My, 760
PROFESSIONAL DEVELOPMENT OF THE YOUNG ENGINEERING TEACHERS, D. R. Lamb .....N, 274
PROFESSIONAL ENGINEERING ETHICS IN PRACTICE, K. A. Meade .....O, 140

RECOGNITION AND INCENTIVES FOR GOOD TEACHING, Survey, H. W. Case .S, 81
RECOGNIZING POTENTIAL ENGINEERS AMONG SCIENCE STUDENTS, R. D. MacCurdy .....N, 255
REPORT OF AUDITOR .....D, 397
REPORT OF THE COMMITTEE ON ATOMIC ENERGY EDUCATION, P. N. Powers.....N, 281
REPORT OF ECRC, H. K. Work ....N, 279
REPORT, ETHICS COMMITTEE .....S, 61
REPORT, ENGINEERING SCHOOL LIBRARIES COMMITTEE, J. H. Moriarty D, 396
REPORT, EVALUATION, ENGINEERING EDUCATION .....S, 25
REPORT OF THE SECRETARY, 1954/55 O, 190
REPORTS OF THE VICE PRESIDENTS ..O, 194
REPORT, YET COMMITTEE, P. Weinberg .....N, 283
RESOLUTIONS COMMITTEE REPORT ..O, 203
REVISED ASTE DATA INDEX .....M, 572
"RISK ANALYSIS," DISCUSSION OF ..Je, 859
RISK ANALYSIS IN ENGINEERING ECONOMY STUDIES, F. A. Gitzendanner .....O, 182
ROLE OF COLLEGES IN NUCLEAR ENGINEERING EDUCATION, G. A. Hawkins .....O, 123
ROLE OF PHYSICS IN ENGINEERING EDUCATION, AIP Committee .....M, 592
ROYS, FRANCIS W., V. P. .....My, 801
RUSSIAN SECONDARY EDUCATION ...Ja, 507

SECTION MEETINGS ....S, 106; O, 210; N, 308; D, 411; Ja, xi; M, ix; A, 618; My, ix
SENTENCE LENGTH IN SCIENTIFIC WRITING, Harry F. Arader .....M, 560
SMALL COMPANY LOOKS AT ENGINEERING EDUCATION, John L. McLucas .....Ja, 458
SPECIALISTS IN DIVERSIFICATION, H. A. Foecke .....N, 270
SPONSORED RESEARCH IN ENGINEERING COLLEGES, W. L. Everitt ....My, 779

TEACHING BASIC ELECTRIC AND MAGNETIC FIELDS—A CHALLENGE, S. Seely .....O, 176
TEACHING ENGINEERING SCIENCES, Sheldon S. L. Chang .....Ja, 456
TEACHING LEADERSHIP TO ENGINEERING STUDENTS, R. K. Watkins ..D, 391
TEACHING POSITIONS AVAILABLE ..S, 103; O, 209; N, 305; D, 406; Ja, 480; M, 576; A, 615; My, 802; Je, 865
TEACHING TIPS, F. H. Pumphrey ...S, 93
TECH. INSTITUTE BULLETINS .....Ja, 483
TECHNICAL WRITING COURSE THAT WORKS, Ray Sweigert, Jr. N, 262
TESTS FOR GUIDANCE AND COUNSELING, Marvin D. Dunnette .....Ja, 434
THERMODYNAMIC METHOD OF ATTACK, A. K. Oppenheim .....D, 332
TORGENSEN HONORED .....M, 568
TRACY, JOHN CLAYTON .....M, 584
TRENDS IN ENGINEERING EDUCATION, V. L. Parsegian .....Ja, 461

UNCONSCIOUS ART, Lee Harrisberger ..... My, 796
UNESCO AND ASEE, Howard K. Justice ..... My, 776
UNIVERSITY RESPONSIBILITY IN CONTACTING HIGH SCHOOLS, J. F. Downie Smith ..... S, 64
UNIVERSITY TECHNICAL WRITERS AND EDITORS, L. A. Rose ..... O, 146
USE OF COMPUTERS IN HANDLING STATISTICAL DATA, W. W. Baker .. O, 163
USES OF THE LABORATORY IN TEACHING ELECTRIC MACHINERY COURSES, L. A. Finzi ..... D, 321

VALUE OF RESEARCH TO GRADUATE INSTRUCTION, W. G. Pollard .... N, 226
VALUE OF RESEARCH TO THE EDUCATION PROGRAM, J. C. Warner .. D, 338
VALUE OF RESEARCH TO THE INSTITUTION, G. H. Hickox ..... N, 222
VAN LEER, BLAKE R. ..... A, 614
VDI CENTENARY CELEBRATION ... My, 786
VOLUMETRIC EFFICIENCY—AMBIGUOUS TERM, R. P. Bobco and A. L. Gosman ..... M, 565

WALKER, V.-P. PENN. STATE ..... Ja, 416
WAYS TO IMPROVE STATUS OF THE GOOD TEACHER, L. H. Johnson ..... O, 132
WEBER, PAUL, PRESIDENT ..... My, 801
WHAT INDUSTRY EXPECTS OF THE YOUNG GRADUATE ENGINEER, John Gammell ..... S, 86
WHERE ARE WE GOING IN ENGINEERING EDUCATION?, R. L. Sweigert N, 247
WHY DO ENGINEERS DISLIKE TECHNICAL WRITING, H. M. Friend ..... Je, 836

YOU CAN'T DO IT ALL AT ONCE, R. T. Howe ..... Ja, 472
YET CONTEST RULES ..... Ja, 508
YOUNG ENGINEERING TEACHER, P. Weinberg ..... D, 363
YET-ITUDES ..... O, 160
YET-ITUDES, P. L. Balise ..... S, 73
YET-ITUDES, M. Baker ..... N, 301
YET-ITUDE: YOU CAN'T DO IT ALL AT ONCE, R. T. Howe ..... Ja, 472
YET-ITUDE: A BUSMAN'S HOLIDAY, Harold A. Foecke ..... M, 573
YET-ITUDE: THE UNCONSCIOUS ART, Lee Harrisberger ..... My, 796

AUTHOR INDEX

ALLEN, F. E., Corrosion Instruction in Engineering Colleges ..... N, 267
ARADER, HARRY F., Sentence Length in Scientific Writing ..... M, 560
ARIES, R. S., Economics in Chemical Engineering ..... Ja, 446
ARMSBY, H. H., Engineering Enrollments and Degrees, 1955 ..... F, 509
ARMSBY, H. H., Future Scientists of America Foundation ..... Je, 855

BAKER, M., YET-itudes ..... N, 301
BAKER, W. W., Use of Computers in Handling Statistical Data .... O, 163
BALISE, P. L.' YET-itudes ..... S, 73
BOBCO, R. P., Volumetric Efficiency-Ambiguous Term ..... M, 565
BOLTON, J. H., The Art of Writing .O, 171
BORING, M. M., Year of Decision ...S, 4
BRANDENBURG, P. F., "Case Studies" in Materials Laboratory ..... M, 563
BURINGTON, R. S., For What Types of Careers Should We Train Mathematicians? ..... O, 115

CASE, H. W., Good Teaching Survey .S, 81
CHANG, SHELDON S. L., Teaching Engineering Sciences ..... Ja, 456
Cziner, R. M., Economics in Chemical Engineering ..... Ja, 446

DAVIS, J. H., General Studies for Engineers ..... O, 109
DAVIS, J. H., Need for More "Know-Why" ..... My, 790
DAVIS, WATSON, High School Science Fairs ..... O, 179
DEAN, J. E., Candid Comments .... S, 99
DOUGHERTY, N. W., Presidential Address ..... S, 8
DUNNETTE, MARVIN D., Tests for Guidance and Counseling ..... Ja, 434

EMBLER, WELLER, Another Look at General Studies ..... M, 551
ENGSTROM, E. W., Industrial Research and a Profile of the Research Worker ..... D, 311
EVERITT, W. L., Sponsored Research in Engineering Colleges ..... My, 779

FAIRBANKS, H. V., Place of Solid State Physics in Engineering .....N, 251
FINZI, L. A., Uses of the Laboratory in Teaching Electric Machinery Courses .....D, 321
FLANAKIN, H. A. M., Birth of a Research Project .....D, 358
FOECKE, H. A., Specialists in Diversification .....N, 270
FOECKE, H. A., YET-itude: A Busman's Holiday .....M, 573
FOOTE, FRANK G., Problems in Nuclear Metallurgy .....My, 760
FRIEND, H. M., Why Do Engineers Dislike Technical Writing? ....Je, 836
FRITZ, R. J., Mechanical Engineers and Nuclear Power Reactor Design .Je, 827

GAMMELL, JOHN, What Industry Expects of the Young Graduate Engineer .....S, 86
GITZENDANNER, F. A., Risk Analysis in Engineering Economy Studies .O, 182
GILMER, B. VON H., Human Relations in Engineering .....M, 544
GOSMAN, A. L., Volumetric Efficiency-Ambiguous Term .....M, 565

HARDENBERGH, D. E., Physics for Engineers .....D, 349
HARRISBERGER, LEE, YET-itude: The Unconscious Art .....My, 796
HARTWELL, R. W., Needs of Electric Power Industry for Nuclear Engineers .....O, 152
HAWKINS, G. A., Role of Colleges in Engineering Education .....O, 123
HAWKINS, G. A., Designing the Educational Program .....N, 241
HAZEN, HAROLD L., ECPD Accreditation-Introduction .....My, 814
HICKOX, G. H., Value of Research to the Institution .....N, 222
HOLLISTER, S. C., ECPD—Toronto Address: Need for Appraisal ....Ja, 503
HOWE, R. T., YET-itude: You Can't Do It All at Once .....Ja, 472
HOWLAND, W. L., Operation Cooperation .....Ja, 467
HUNT, D. C., Cooperative Engineering Calendars .....O, 168

ISBIN, H. S., Nuclear Engineering Research, Survey .....S, 76

JARACZ, W. A., Engineering Enrollments and Degrees, 1955 .....F, 509
JOHNSON, A. P., Prediction of Engineering Potentiality in High School Students .....O, 135
JOHNSON, L. H., Ways to Improve Status of the Good Teacher .....O, 132
JUSTICE, HOWARD K., UNESCO and ASEE .....My, 776

KALSEM, P. J., Educational Requirements for Technical Editors ..Je, 832
KARN, H. W., Human Relations in Engineering .....M, 544
KEREKES, FRANK, English Program as Engineering Teachers View It .Ja, 427
KILLIAN, JAMES R., JR., Liberal Scientific Education .....My, 793
KIMBARK, E. W., Engineering Education in Brazil .....D, 353
KIRKBRIDE, C. G., Education for Research in Industry .....N, 216

LAMB, D. R., Professional Development of Young Engineering Teachers N, 274
LESSER, ARTHUR, JR., Engineering Economy Committee Functions ....Ja, 498
LEVINE, M., Candid Comments ...D, 402

MACCURDY, R. D., Recognizing Potential Engineers .....N, 255
MATTILL, J. I., 63rd Annual Meeting S, 14
MCCABE, W. L., ECPD—Resolution; Origins of Proposal .....Ja, 501
MCLAIN, STUART, Problems in Nuclear Metallurgy .....My, 760
MCLUCAS, JOHN L., Small Company Looks at Engineering Education Ja, 458
MCNEARY, M., Graphic Science ...N, 303
MEADE, K. A., Professional Engineering Ethics in Practice .....O, 140
MORGEN, R. A., Industrial Fellowship Announcement .....Ja, 496
MORIARTY, J. H., Report, Engineering School Libraries Committee ...D, 396

OPPENHEIM, A. K., Thermodynamic Method of Attack .....D, 332

PARÉ, EUGENE, Graphic Science: Course for Science Majors .....My, 798
PARSEGIAN, V. L., Trends in Engineering Education .....Ja, 461
PEARSON, D. S., Cracking the Creative Nut .....O, 121
PLETTA, D. H., Mechanics Teachers—Their Cross and Their Crown .Ja, 453
POLLARD, W. G., Value of Research to Graduate Instruction .....N, 226

POSEY, CHESLEY J., On Teaching Design .....M, 547
POULTON, J. F., Coordination of Architecture, Engineering, and Construction by the Project Method ...D, 383
POWERS, P. N., Committee on Atomic Energy Education .....N, 281
PUMPHREY, F. H., Teaching Tips ...S, 93

REID, ROBERT C., MIT's Practice School Ja, 441
RETTALIATA, J. T., Education by Research Training .....D, 327
RISING, E. J., Our Output Problem .D, 379
RISING, E. J., Corps of Engineers Student Program .....My, 771
ROHDE, F. VIRGINIA, Mathematics Teacher in Engineering .....M, 555
ROSE, L. A., University Technical Writers and Editors .....O, 146
RUBEY, H., Enrollment and Incomes in Civil Engineering Can Be Increased .....N, 236

SAUER, J. A., Physics for Engineers .D, 349
SAVILLE, THORNDIKE, ECPD—Proposal for Survey of Profession .....Ja, 500
SEEGER, R. J., On Teaching Physical Mechanics .....Je, 842
SEEGER, R. J., Physics is Not Engineering .....O, 127
SEELY, S., Teaching Basic Electric and Magnetic Fields—A Challenge ..O, 176
SHIMIZU, KINJI, Influence of ASEE Mission Report on Japanese Engineering Education .....N, 260
SMITH, G. WALLACE, Survey in Engineering Mechanics .....M, 536
SMITH, J. F. DOWNIE, University Responsibility in Contacting High Schools .....S, 64

SNELL, J. R., Fight for Ethics .....N, 230
STREET, WM. E., Graphic Science: Chairman's Message .....Ja, 475
SÜSSKIND, CHARLES, Microwave Engineering .....Je, 838
SWEIGERT, R. L., Where Are We Going in Engineering Education? ....N, 247
SWEIGERT, RAY, JR., Technical Writing Course That Works .....N, 262

UPSON, R. H., Candid Comments ..D, 401

VAN VLECK, J. H., Blurred Borders of Physics and Engineering .....D, 366
VREELAND, R. P., Descriptive Geometry Helps Surveying Instructor ....S, 100
WAGNER, H. A., Needs of Electric Power Industry for Nuclear Engineers .....O, 152
WALKER, ERIC A., Can 500,000 Engineers Be Professional? .....Ja, 421
WARNER, J. C., Value of Research to the Education Program .....D, 339
WATKINS, R. K., Teaching Leadership to Engineering Students .....D, 391
WEINBERG, P., Report, YET Committee .....N, 283
WEINBERG, P., Young Engineering Teacher .....D, 363
WHITE, ARDIS, Field Research in Civil Engineering .....My, 768
WILSON, W. E., Communication Problems in the Engineering Science Curriculum .....D, 374
WOLFE, J. K., Evaluation of Engineering Education .....D, 342
WORK, H. K., Report ECRC .....N, 279

ZIMMERMAN, JOSEPH F., Extra-Curricular Activities .....My, 787

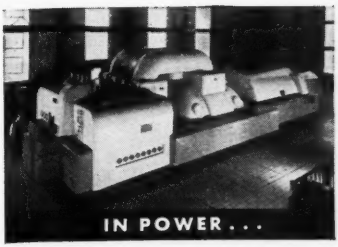
SECTION MEETINGS

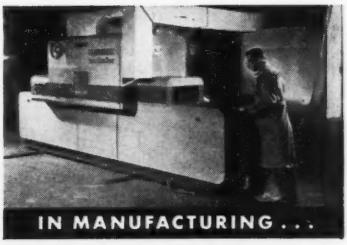
Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Pennsylvania State University	April 26–27, 1957	B. A. Whisler, Pennsylvania State University
Illinois-Indiana	Purdue University	May 12, 1956	O. W. Witzell, Purdue University
Kansas-Nebraska	University of Wichita	Oct. 26–27, 1956	J. K. Ludwickson, University of Nebraska
Michigan	Wayne University	May 5, 1956	G. H. Howell, Wayne University
Middle Atlantic	Bell Telephone Laboratories, Murray Hill, N. J.	May 12, 1956	G. B. Thom, Newark College of Engineering
Missouri-Arkansas	University of Arkansas	April 6, 1957	L. R. Heiple, University of Arkansas
National Capital Area	Capital Radio Engineering Institute, Wash., D. C.	Oct. 11, 1955	W. J. Huff, University of Maryland
New England	Tufts University	Oct. 19–20, 1956	W. S. Evans, University of Maine
North Midwest	State University of Iowa	Oct. 12–13, 1956	J. W. Howe, State University of Iowa
Ohio	University of Toledo	April 26–27 1957	E. D. Harrison, University of Toledo
Pacific Northwest	University of Washington	May 10, 11, 12, 1956	M. C. Jenson, Washington State College
Pacific Southwest	University of Arizona	Dec. 28–29, 1956	D. Whelan, Loyola University of Los Angeles
Rocky Mountain	Denver University	April 28, 1956	W. H. Parks, University of Denver
Southeastern	Tulane University	April 5, 6, 7, 1956	D. W. Dutton, Georgia Institute of Technology
Southwest	Texas A. & M. College	April 18–19, 1957	E. M. Thomas, Texas Western College
Upper New York-Ontario	Schenectady New York	Oct. 12–13, 1956	W. H. Branch, General Electric Company

Members of the Society are welcome at all Section Meetings

ASEE CALENDAR OF EVENTS, 1956–1957

Meeting	*Date*	*Location*	*Chairman or Information*
Fall, 1956			
North Midwest Section	Oct. 12–13	State University of Iowa	J. W. Howe, State University of Iowa
Upper New York-Ontario Section	Oct. 12–13	Schenectady, N. Y.	W. H. Branch, General Electric Co.
New England Section	Oct. 19–20	Tufts University	W. S. Evans, U. of Maine
Kansas-Nebraska Section	Oct. 26–27	University of Wichita	J. K. Ludwickson, U. of Nebraska
Pacific Southwest Section	Dec. 28–29	University of Arizona	D. Whelan, Loyola University of Los Angeles
Winter, 1957			
Relations With Industry Division, College-Industry Conference	Jan. 30–31	University of California (Los Angeles)	W. W. Burton, Minn. Mining & Manufacturing
Cooperative Engineering Education Division	Jan. 10–11	Northeastern University	R. G. Owens, Illinois Institute of Technology
Engineering Drawing Division	Feb. 1–2	Rice Institute	W. E. Street, Texas A. & M. College
Spring, 1957			
Missouri-Arkansas Section	April 6	University of Arkansas	L. R. Heiple, U. of Arkansas
Southwest Section	April 18–19	Texas A. & M. College	E. M. Thomas, Texas Western
Allegheny Section	April 26–27	Penn State University	B. A. Whisler, Penn State U.
Ohio Section	April 26–27	University of Toledo	E. D. Harrison, U. of Toledo
Illinois-Indiana Section	May		O. W. Witzell Purdue University
ASEE ANNUAL MEETING	JUNE 17–21, 1957	CORNELL UNIVERSITY	





Graduates shape their Futures at Allis-Chalmers

Growth with all the world's basic industries . . . choice of training assignments . . . opportunities in a variety of engineering fields—only at Allis-Chalmers can your graduates find such broad career possibilities. A-C's graduate training course allows them to develop engineering skill through application of theoretical knowledge. For example:

THERMODYNAMICS—steam turbines, internal combustion engines.
ELECTRICITY—transformers, motors, generators.
HYDRAULICS—hydraulic turbines, centrifugal pumps.

—and more make up a course designed to develop leaders in research, engineering, production and sales.

Get more information from the Allis-Chalmers representative visiting your campus, or write Allis-Chalmers, Graduate Training Section, Milwaukee 1, Wisconsin.

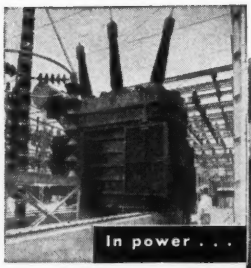
BASIC INFORMATION about Allis-Chalmers GTC

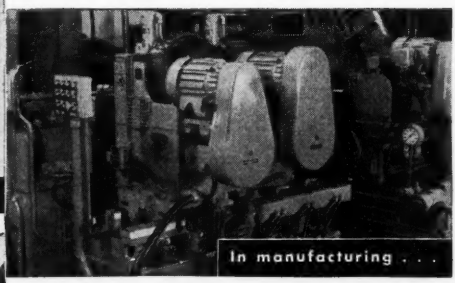
THE COURSE—Offers maximum of 24 months' training. Established in 1904. Recognized as a model for industry since that time.

OBJECTIVES—Program is designed to put the right man in the right job and develop men of management caliber.

OPTIONAL PROGRAM — Trainee plans own program and may revise it with changing interests. Competent counselors are always available.

RESULTS—Many members of Allis-Chalmers management team are graduates of this program. 5026





Graduates can build "Tomorrow" at Allis-Chalmers

Only at Allis-Chalmers can your graduates find all these broad career possibilities — growth with all the world's basic industries . . . wide range of products . . . choice of training assignments . . . professional advancement . . . opportunities in a variety of engineering fields.

A-C's Graduate Training Course allows them to develop engineering skill through application of theoretical knowledge. For example:

ELECTRICITY — transformers, motors, generators.

THERMODYNAMICS — steam turbines, internal combustion engines.

HYDRAULICS — hydraulic turbines, centrifugal pumps.

These, and many more, make up a course designed to develop the industrial leaders of the future in research, engineering, production and sales.

Get more information from the Allis-Chalmers representative visiting your campus, or write Allis-Chalmers, Graduate Training Section, Milwaukee 1, Wisconsin.

BASIC INFORMATION about Allis-Chalmers GTC

A-5025

THE COURSE — Offers maximum of 24 months training. Established in 1904. Recognized as a model for industrial training courses since that time.

OBJECTIVES — Program is designed to put the right man in the right job and develop men of management caliber.

OPTIONAL PROGRAM — Trainee plans own program and may revise it with changing interests. Competent counselors are always available.

RESULTS — Many members of Allis-Chalmers management team are graduates of this outstanding program.

RADIO'S ONE-WAY STREET

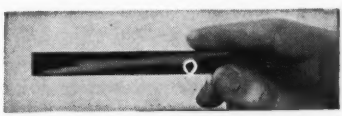
Dr. S. Weisbaum assembles an isolator which he developed for use in a new microwave system. Dr. Weisbaum is a Ph.D. in microwave spectroscopy from New York University. He is one of many young men at Bell Laboratories applying the insight of the physicist to develop new systems of communication.

New radio relay systems for telephone and television now in the making will employ an ingenious device invented by Bell scientists. The device, known as an "isolator," senses which way microwaves are traveling through a waveguide, and stops those going the wrong way.

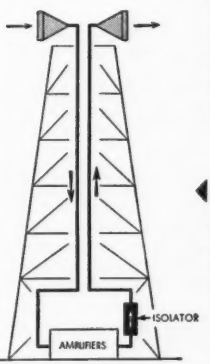
In the new systems a klystron wave generator sends signals through a waveguide to the antenna. The klystron must be shielded from waves reflected back along the waveguide by the antenna. The isolator stops reflections, yet allows the signals to go through clear and strong.

This isolator is a slab of ferrite which is mounted inside the waveguide, and is kept magnetized by a permanent magnet strapped to the outside. The magnetized ferrite pushes aside outgoing waves, while unwanted reflected waves are drawn into the ferrite and dissipated. This "field displacement" action results from the interplay between microwaves and a ferrite's spinning electrons.

This is another example of how Bell Telephone Laboratories research works to improve American telephony and telecommunications throughout the world.



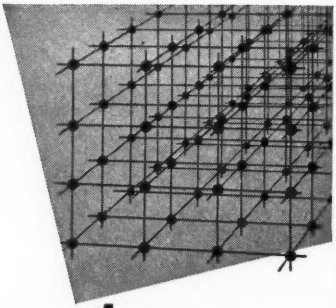
The heart of the isolator is a ferrite slab. Geometric pattern is a carbon layer which dissipates reflected signals.



At a radio relay station an isolator assures one-way transmission from the output of the amplifier to the antenna.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT



nuclear
CAREERS for
SCIENTISTS and ENGINEERS

At COMBUSTION ENGINEERING'S new Nuclear Engineering and Development Center, Windsor, Connecticut, permanent openings for SENIOR AND JUNIOR POSITIONS are available to qualified

Aeronautical Engineers	Mechanical Engineers
Chemical Engineers	Metallurgists
Chemists	Naval Architects
Design Engineers	Nuclear Engineers
Electrical Engineers	Physicists
Mathematicians	Structures Engineers

Here is your opportunity to help develop a new NAVAL NUCLEAR PROPULSION SYSTEM — with the first company in the country that will complete such an AEC contract with its own facilities.

You will be a member of a company that is well-established in the Nuclear Power field. Combustion Engineering has accumulated ten years' experience —designing and building major reactor components, both for Naval units and for central stations.

And you'll find Windsor a wonderful place to live. Only 8 miles from Hartford, it is an ideal location, both for work and for play.

If you are a citizen, whether you have Nuclear experience or not—send a complete resume, in strict confidence, to

COMBUSTION ENGINEERING, INC.

Reactor Development Division
Department M, Windsor, Conn.

INDEX OF ADVERTISERS

The Macmillan Company Cover 2
(Atherton & Currier, Inc.)

International Textbook Company i

John Wiley & Sons, Inc. iii, Cover 4
(Waterston & Frisch, Inc.)

Lancaster Press, Inc. iv

The Ronald Press Company v

McGraw-Hill Book Company, Inc. vi, vii, viii

Allis-Chalmers Manufacturing Company xi, xii
(Compton Advertising Agency)

Bell Telephone Laboratories xiii
(N. W. Ayer & Son, Inc.)

Combustion Engineering, Inc. xiv
(G. M. Basford Company)

Boeing Airplane Company xv
(N. W. Ayer & Son, Inc.)

D. Van Nostrand Company, Inc. xvi
(Albert Frank-Guenther Law, Inc.)

Prentice-Hall, Inc. Cover 3
(Albert Frank-Guenther Law, Inc.)

SERS
over 2
)
i
Cover 4
.)
iv
v
y,
vii, viii
ng
xi, xii
es xiii
c.)
nc. xiv
ny)
xv
nc.)
y,
xvi
er
Cover 3
er

Boeing offers long-range engineering careers

Scores of Boeing engineers today are enjoying intriguing and rewarding careers because of sound advice given them 10, 15 or 20 years ago by their college professors and placement officers.

Today your students will find in aviation—and Boeing—still greater opportunity and growth potential.

Boeing today employs more engineers than at the peak of World War II. One out of each seven employees is an engineer! And stability has long marked an engineering career here. Forty-six per cent of Boeing engineers have been with the company for more than five years; 25% for more than 10 years; 6% more than 15 years. There are a number with 20, 25 and even 30 years' service.

What kind of work does Boeing offer? Opportunity lies in three basic areas: Research, Design and Production. Programs include multi-jet bombers, America's first jet transport, the Bomarc pilotless aircraft guided missile system; application of nuclear power and supersonic flight.

Boeing is continually seeking engineers of ability—electrical, civil, mechanical, aeronautical and related fields, as well as physicists and mathematicians with advanced degrees.

Engineers are encouraged to take daytime graduate studies during working hours and are reimbursed for all tuition expenses. May we send you—or any of your students—additional information about engineering careers at Boeing? Just write:

JOHN C. SANDERS, *Staff Engineer—Personnel,*
Boeing Airplane Company, Seattle 14, Wash.

BOEING

A PIONEER SERIES IN A FAST MOVING FIELD OF NATIONAL IMPORTANCE

Principles of GUIDED MISSILE DESIGN

Edited by GRAYSON MERRILL, *Captain, USN*

A six volume series on the current worthwhile unclassified information on guided missile technology written by nationally known authorities.

Latest book just published:

AERODYNAMICS, PROPULSION, STRUCTURES AND DESIGN PRACTICE *by* E. A. BONNEY, *Johns Hopkins University;* M. J. ZUCROW, *Purdue University;* and C. W. BESSERER, *Ramo-Wooldridge Corporation.*

A comprehensive treatment of three basic elements of missile design providing the latest information on their fundamentals.
640 *pages, illustrated,* $12.50

Already published:

GUIDANCE

By ARTHUR S. LOCKE, *Vitro Laboratories* and contributing authors

"An absolute 'must' in every guided missile library"—Ordnance.
746 *pages, illustrated,* $12.50

—forthcoming—

OPERATIONS RESEARCH, ARMAMENT, LAUNCHING (Merrill, Goldberg & Helmholz)

SYSTEMS ENGINEERING, RANGE TESTING (Jerger and Freitag)

SPACE FLIGHT (Ehricke)

GUIDED MISSILE DESIGNER'S HANDBOOK (Besserer)

write for on approval copies

D. VAN NOSTRAND COMPANY, INC.
PRINCETON, NEW JERSEY

e 1956

G
E

tion
ties.

DE-
ver-
RER,

sign

ting

-
er

s-

C.

Prentice-Hall

MATERIALS OF ENGINEERING

By CARL A. KEYSER, University of Massachusetts

Emphasizing practical applications, this new text offers a fully integrated presentation of the properties, fabrication, uses and testing of all the ordinary materials in engineering use. OUTSTANDING FEATURES: Uses solid state concepts insofar as they can be applied in a descriptive non-mathematical way. Material is arranged logically for suitable use in different courses. Clear, concise summaries, carefully chosen questions with problems at end of each chapter. Tells how properties of materials limit selection of processing methods. Describes how different processing methods affect service properties of various materials.

480 pages . 5⅝″ x 8⅜″ . Publ. June 1956

SURVEYING: An Introduction to Engineering Measurement

By ADRIAN R. LEGAULT, HOWARD M. McMASTER, and RALPH R. MARLETTE, Department of Civil Engineering, University of Nebraska

Logically divided into three parts this new text covers: The Engineer and Surveying, Measurements, and Applications. Part I—Historical background and brief descriptions of the basic types of surveys lead to the early coverage of fundamentals of measuring and computation including error theory. Part II—Basic Operations, instruments and techniques involved in measuring distance, direction and elevation are discussed in detail. Field adjustments of instruments outlined. Part III—Coordination and stress of the application of the basic material covered in Parts I and II.

IN THE PRENTICE-HALL CIVIL ENGINEERING SERIES
Edited by N. M. NEWMARK

448 pages . 6″ x 9″ . To be published August 1956

REFRIGERATION & AIR CONDITIONING, 2nd Ed.

By RICHARD C. JORDAN, University of Minnesota, and GAYLE B. PRIESTER, Baltimore Gas & Electric Co.

Here is a thorough revision of the best-selling text that has been adopted in virtually every engineering school in the United States. Its revisions include: inclusion of modern developments, new illustrations of modern equipment, more complete data on Freon-22 and brines plus expanded material on psychometry and helium liquefaction, latest revised table of refrigerants, new section on residential air conditioning and new material on capillary tubes and air cycle refrigeration. Book is teachable and flexible, answers to half the problems are given, there are many new illustrations and a wealth of references.

576 pages . 6″ x 9″ . To be published August 1956

For approval copies write

Prentice-Hall, Inc. ENGLEWOOD CLIFFS, NEW JERSEY

WILEY BOOKS

FOUNDATIONS: Design and Practice

By Elwyn E. Seelye, *Seelye Stevenson Value & Knecht, Consulting Engineers.* This is the first complete textbook on foundations. It covers design, construction methods, costs, specifications, and field practice. Clear and authoritative, it is written out of the author's vast store of personal experience. Hundreds of carefully worked out drawings illuminate and simplify the text material. *1956. 466 pages. $16.00.*

CAMS: Design, Dynamics, and Accuracy

By Harold A. Rothbart, *The City College of New York.* A completely modern approach to cam analysis, stressing dynamics, machine design, and computors. The author provides a lucid coverage of both theoretical and practical aspects of the subject. Of special value is the discussion of profile accuracy and errors. Mathematics is kept to a minimum throughout the text. Representing a significant extension of the usual kinematic treatment of cam action, this work answers a growing need for today's engineering student. *1956. In Press*

RURAL WATER SUPPLY AND SANITATION, 2nd Edition

By Forrest B. Wright, *Cornell University.* Almost entirely rewritten, the second edition includes new chapters on the importance of water, development of source of water, water treatment, and problems of head and pressure. New problems and a large number of up-to-date illustrations have also been included. *1956. Approx. 358 pages. Prob. $4.90.*

APPLIED ELECTRICAL MEASUREMENTS

By Isaac F. Kinnard, *General Electric Company.* Provides a broader background in applied electrical measurements than any other single volume. The author covers the theory of measurements, the measurements of electrical quantities, and the measurement of non-electrical quantities by electrical means. *1956. Approx. 594 pages. Prob. $15.00.*

Send today for your examination copies.

See page iii for news of other Wiley Books.

JOHN WILEY & SONS, Inc., 440-4th Ave., New York 16, N.Y.

sulting
ations.
s, and
of the
refully
aterial.

A com-
namics,
lucid
ubject.
errors.
Repre-
nent of
gineer-

tion

ely re-
ortance
t, and
number
. *Ap-*

vides a
an any
easure-
easure-
. *Ap-*

6, N.Y.